METAL PROGRESS

VOLUME 32

July 1937 to December 1937

Ernest E. Thum
Editor

William H. Eisenman
Business Manager

Metal Progress Is Owned, Published and Copyrighted by

THE AMERICAN SOCIETY FOR METALS
7016 Euclid Avenue, Cleveland, Ohio

(The American Society for Metals is not responsible for statements or opinions printed in this publication)

Table of Contents for Volume 32

67:33 Brass Sheet, Relationship Between Hardness and Tensile Properties, a letter from L. Loskiewicz 272
200-In. Telescope, World's Largest, Has Mounting of Welded Steel, by G. H. Froebel 132
A-B-C of Corrosion and Heat Resisting Steels, by F. R. Palmer; Data Sheet 524
Advances in Aluminum Alloys in England, by S. L. Archbutt and A. G. C. Gwyer; abstract from papers for International Association for Testing Materials 286
Advances in Carbon Steel Manufacture and Application, by Richard W. Simon 431
An Industry Comes of Age, Enamelers Meet in Open Forum, by Charles S. Pearce 42
Analyses of S.A.E. Steels; Data Sheet 449
Annealing of Nickel Silver, by Maurice Cook; abstracted from paper for Institute of Metals 192
Approximate Critical Temperatures for S.A.E. Steels, by M. J. R. Morris, R. Sergeson and G. W. Gable; Data Sheet 462
Arc Welding Continually Advances in Pipe Line Construction, by Alton F. Davis 46
Breaking-In Copper-Lead Bearings, a letter from C. P. Geen 785
Carbon-Free Alloys Hard as Toolsteel, by Wesley P. Sykes; summary of Campbell Memorial Lecture 649
Chart Classifying the Principal Welding Processes, by F. T. Llewellyn; Data Sheet 554
Classification of American Toolsteels, by James P. Gill; Data Sheets 458, 459
Columbium in Steels, Plain Chromium and Chromium-Nickel, by W. D. Wilkinson, Jr. 661
Common Machine Bolts; photographic story by Van Fisher 761
Compounding of Metal Powders; Editorial note 131
Controlled Grain Size in Steel, by T. Swinden and G. R. Bolsover; abstract from *Journal* Iron and Steel Institute 174
Controlled Hardening of Tools—I. The Atmosphere, by Fred M. Reiter; II. The Steel, by L. H. Grenell; III. The Results, by E. C. Adkins 240
Convention Comment 645
Copper-Lead Bearing Metals Favored for Severe Service, by Francis G. Jenkins 145
Copper-Lead Bearing Metals, Some Points on Automotive Practice, a letter from J. L. McCloud 267
Corrosion Resistance of Stainless Steel; Data Sheet 605
Creusot Centenary, a letter from Albert Portevin 681
Crucible Toolsteel, by H. C. Bigge 773
Crystallography of the Chemical Elements, Groups I, II and III by William Hume-Rothery; Data Sheet 490
Crystallography of the Elements, Groups IV to VI, by William Hume-Rothery; Data Sheet ..57, 492
Crystallography of the Chemical Elements, Groups 7 and 8, adapted from William Hume-Rothery; Data Sheet 157, 494
Damping Capacity, Its Practical Importance, by O. Föppl; abstract from *Journal* Iron & Steel Institute 262
Delray Turbine Blades, a letter from W. J. Dawson 167
Developments in Non-Ferrous Alloys (Heavy Metals), by D. K. Crampton 569
Diagnosis of Metal Trouble in Industry, Part III Carburizing, by J. L. Burns and V. Brown 151
Directional Properties in Brass Strip, a letter from J. D. Jevons 164
Discussion Invited; Editorial note . 239
Divergence of European Standards, a letter from Federico Giolitti .. 164
Diversification of Stainless for Special Purposes, by Ernest E. Thum 597
Draw Temperatures for S.A.E. 1050 Basic Steel Forgings, by Joseph A. Duma; Data Sheet 346
Ductile Zinc Coatings, a letter from W. M. Peirce 679
Economics of Welding, by C. C. Brinton; abstract of paper for American Society of Mechanical Engineers 780
Electric Furnaces in the Foundry, Advantages and Disadvantages; notes from an address by Richard Schneidewind 665
Electric Pig Iron, Performance of Italian Shaft Furnaces, a letter from Federico Giolitti 268
Electron Diffraction, a New Tool for Research, by C. S. Barrett 655
Embrittlement of Steels at High Steam Temperature, a letter from J. H. G. Monypenny 67
Equilibria for Gas-Steel Reactions; Data Sheet 378
Equilibrium Diagram for Steel (Iron and Iron Carbide); Data Sheet.. 342
Erroneous Interpretations of Studies Under Polarized Light, a letter from Albert M. Portevin 63
Evolution of Gun Steel, a letter from Albert Portevin 783
Exposure Chart for Radiography of Steel, by Herbert R. Isenburger; Data Sheet 498
Factors Relating Impact Strength of Metals With Their Service, a report by the Editor 138
Fine Dispersion of Lead in Copper Caused by Lithium, a letter from Harold J. Ness 678
Fluxes for Soft Solder, by J. W. Willstrop, A. J. Sidery, and H. Sutton; abstract from *Journal* Institute of Metals 52
Foundry Work on High Chromium-Iron Castings, by John Sissener.. 521
Free-Cutting Aluminum Alloys, a letter from Hans Diergarten .. 165
Furnace Practices Improve Forgings, by Lloyd E. Raymond 373
George Booker Waterhouse, President A.S.M. 666
Good and Bad Actions of Aluminum in Steel Castings; notes from a discussion led by C. E. Sims 674
Hardening of Steel in Theory and Practice, a letter from Hans Diergarten 682
Hardness Conversion Chart for Steels; Data Sheet 338
Have You Ever Thought About Silver? Editorial review 35
Heat Treatment and Metallurgical Control, by O. N. Peterson 337
High Frequency Melting, by N. Broglio; abstracted from Report No. 17 to International Foundry Congress, 1936 meeting 772
High Grade Zinc Electrically Smelted, by W. S. Landis; abstract of paper before American Electrochemical Society 776
Historical Development of High Speed, by H. C. Bigge 455
How About Bearings? Editorial note 249
Identification of Constituents in Aluminum Alloys, by F. Keller and G. W. Wilcox; Data Sheet .. 579
Improved Illumination for Microscopes, by Peter P. Tarasov 266
Improvements in Forging Methods, by Adam M. Steever 413
Incipient Fracture Revealed by X-Rays, by H. J. Gough; abstract from paper for International Association for Testing Materials .. 276
Influence of Cold Work on Austenitic Grain Size, a letter from Albert Portevin 166
Instrumentation, Exact Science Combined With Fine Art, by M. F. Behar and Richard Rimbach ... 487
Internal Fissures Induced in Rails by Soaking in Hydrogen, from report by H. F. Moore 159
Interrupted Spot Welding Uses Electron Tube Control, by R. S. Pelton 59
Izod Toughness Vs. Tensile Strength of Heat Treated S.A.E. Steels; Data Sheet 452
John B. Tytus, Builder of First Continuous Wide-Sheet Mill 142
Lead Bronzes in England and Germany; abstract of paper by D. P. C. Neave, *Journal* Institution of Automobile Engineers; paper by Willi Claus, *Metallwirtschaft;* and comment in *The Metallurgist* ... 149
Mechanism of "Peeling" of a Zinc Coating, a letter from George F. Comstock 162
Metal Cans for Food; abstract of address by Robert S. Williams .. 666
Metal Yachts Race for the Cup, by John Scott Hughes 252
Method for Identification of Inclusions in Iron and Steel; Data Sheet 434
Microscopic Imperfections in Metallic Crystals, by Norman P. Goss 41
Microstructure of High Purity Iron-Carbon Alloys, by Harry K. Herschman; Data Sheet 781
Microstructure of Low Alloy and High Strength Cast Iron; Data Sheet 260
Microstructure of Nickel and High Nickel-Chromium-Iron Alloys; Data Sheet 330
Modern Refrigeration Needs Modern Metallurgy, by William Mikulas and L. A. Philipp 753
Nature of the Iron-Manganese System, by Francis M. Walters, Jr. 254
New Aspects of Fatigue and Creep; a report by John M. Lessells 257
New Copper Alloys, Age Hardened, Have High Conductivity, by T. S. Fuller 51
New Eyes for Science; Editorial note 238
New Types of Refractories for Openhearths, by Federico Giolitti 384
Nickel-Aluminum Diagram, by Alexander and Vaughan; Data Sheet 673

Nickel-Silicon Diagram, by Iwaze and Okamoto; Data Sheet 675
Note on Production, a letter from Myron Weiss 784
Note on the File Scratch Test, by W. C. Hamilton 265
Oxy-Acetylene Welded Pipe Joints —Scope, Utility and Economics, by T. W. Greene 36
Phosphorus Balance, Basic Steel to Slag, by E. Maurer and W. Bischof; Data Sheet 438
Physical Factors in Casting of Metals, by C. H. Desch; abstract of lecture for Institute of British Foundrymen 144
Powder Metallurgy of Tungsten and Other Refractory Metals, by Samuel L. Hoyt 749
Precise Control of Atmospheres Required to Prevent Surface Reactions, a letter from John H. Whiteley 783
Predicting a Fatigue Failure, Are X-Rays Competent? a letter from Charles S. Barrett 677
Preparation of Furnace Gases for Non-Oxidizing Atmospheres, by E. E. Thum 377
Production Carburizing Revolutionized in 30 Years, by Ernest F. Davis; abstract of paper for Carburizing Symposium 347
Progress in Light Alloys, by A. J. Dornblatt 575
Properties of Aluminum Alloys; Data Sheet 576
Properties of Refractory Materials, Except Fireclay, compiled by Stuart M. Phelps; Data Sheet .. 383
Properties of the Principal Cr-Fe Alloys; Data Sheet 600
Properties of the Principal Cr-Ni-Fe Alloys; Data Sheet 601
Random notes by the Editor; Editorial comment 33
Rapid Arc Welding; Editorial note 239
Refractory Cast Irons, a letter from Federico Giolitti 680
Relative Corrodibility of Some Common Metals and Alloys, by Jerome Strauss; Data Sheet 526
Rules Governing Forging Machine Dies, by E. R. Frost; Data Sheet 416
Scaling of Chromium-Iron; Influence of Carbon Content; abstracted from *The Metallurgist*, October 1937 760
Slag Inclusions in Steel, Standards for Size and Frequency, a letter from Hans Diergarten 269
Smooth and Rapid Flame Cutting of Plate 8 In. Thick, a letter from Hans Diergarten 68
Smooth, Non-Porous Coatings of Tin on Copper; abstract of articles and discussion by W. D. Jones and Edward J. Daniels, *Journal* Institute of Metals 256
Sound Welds in Very Thick Plate a Routine Matter, a letter from H. S. Blumberg 66, 131
Speed of Manual Arc Welding; Data Sheet 562
Spot and Seam Welding (Resistance) of Aluminum Alloy Sheet, by D. I. Bohn 53
Standard Grain Sizes for Steels; Data Sheet 435
Standard Tolerances for Forgings up to 100 Lb.; Data Sheet 414
Standards for Estimating Grain Size (Non-Ferrous); Data Sheet 570
Status of Welding in 1937, by Leon C. Bibber and Elmer Gammeter 551
Structural Diagram for Fe-Cr-C-Si; Data Sheet 528
Surface Hardening With the Oxy-Acetylene Flame, by A. K. Seemann 247
Synthesizing an Alloy to Order; Editorial note 131
Tantalum Irons and Steels, by R. Genders and R. Harrison; summary of paper for British Iron and Steel Institute 56
Temperature Conversion Chart; Data Sheet 348
Tensile and Endurance Properties of Cast Al-Si Alloys, a letter from L. W. Kempf 681
Titanium Does Not Increase Corrosion of 18-8 Stainless Steel, a letter from William B. Brooks 68
Transverse Weakness in Forgings, Physical Properties of Heavy Crankshafts, a letter from Georges Delbart 273
Trends in Alloy Steels in America, by Ernest E. Thum 463
Trends in Alloy Steels in England, by J. H. G. Monypenny 447
Vacuum Annealers; Editorial note 239
Voids in Graphitic Steels, a letter from M. L. Samuels; reply by Mr. Fleischmann 167
Wear Testing, a letter from Samuel J. Rosenberg 65
Weld Structure — a Correction; Editorial note 131
Welding of Cast Iron Discussed at Birmingham, by Raymond L. Rolf 777
Welding Rods and Electrodes; Editorial note 131
Welding Symbols; Data Sheet 555
Where Do We Go From Here? an Editorial 643
Work Sensitivity, Embrittlement by Cold Work, by S. L. Case 669

Index of Authors

Adkins, E. C.
Controlled Hardening of Tools, the Results 245
Alexander and Vaughan
Nickel-Aluminum Diagram; Data Sheet 675
Archbutt, S. L. and A. G. C. Gwyer
Advances in Aluminum Alloys in England; abstract of papers for International Association for Testing Materials 286
Barrett, C. S.
Electron Diffraction, a New Tool for Research 655
Predicting a Fatigue Failure, Are X-Rays Competent? 677
Behar, M. F. and Richard Rimbach
Instrumentation, Exact Science Combined With Fine Art 487
Bibber, Leon C. and Elmer Gammeter
The Status of Welding in 1937 .. 551
Bigge, H. C.
Crucible Toolsteel 773
Historical Development of High Speed 455
Bischof, W. and E. Maurer
Phosphorus Balance, Basic Steel to Slag; Data Sheet 438
Blumberg, H. S.
Sound Welds in Very Thick Plate a Routine Matter 66, 131
Bohn, D. I.
Spot and Seam Welding (Resistance) of Aluminum Alloy Sheet 53
Bolsover, G. R. and T. Swinden
Controlled Grain Size in Steel; abstract from *Journal* Iron and Steel Institute 174
Brinton, C. C.
Economics of Welding 780
Broglio, N.
High Frequency Melting; abstracted from Report No. 17 to International Foundry Congress, 1936 Meeting 772
Brooks, William B.
Titanium Does Not Increase Corrodibility of 18-8 Stainless Steels 68
Brown, V. and J. L. Burns
Diagnosis of Metal Troubles in Industry, Part III Carburizing 151
Burns, J. L. (see above).
Case, S. L.
Work Sensitivity, Embrittlement by Cold Work 669
Claus, Willi and D. P. C. Neave
Lead Bronzes in England and Germany; abstracted from *Journal* Institute of Automobile Engineers, *Metallwirtschaft*, and *The Metallurgist* 149
Comstock, George F.
Mechanism of "Peeling" of a Zinc Coating 162
Cook, Maurice
Annealing of Nickel-Silver; abstract of paper for Institute of Metals 192
Crampton, D. K.
Developments in Non-Ferrous Alloys (Heavy Metals) 569
Daniels, Edward J. and W. D. Jones
Smooth, Non-Porous Coatings of Tin on Copper; abstract of articles and discussion in *Journal* Institute of Metals 256
Davis, Alton F.
Arc Welding Continually Advances in Pipe Line Construction 46
Davis, Ernest F.
Production Carburizing Revolutionized in 30 Years; abstract of paper for Carburizing Symposium 347
Dawson, W. J.
Deiray Turbine Blades 167
Delbart, Georges
Transverse Weakness in Forgings, Physical Properties of Heavy Crankshafts 273
Desch, C. H.
Physical Factors in Casting of Metals; abstract of lecture for Institute of British Foundrymen 144
Diergarten, Hans
Free-Cutting Aluminum Alloys .. 165
Hardening of Steel in Theory and Practice 682
Slag Inclusions in Steel, Standards for Size and Frequency 269
Smooth and Rapid Flame Cutting of Plate 8 In. Thick 68
Dornblatt, A. J.
Progress in Light Alloys 575
Duma, Joseph A.
Draw Temperatures for S. A. E. 1050 Basic Steel Forgings 346

Editorial Comment
Discussion Invited; How About Bearings? Rapid Arc Welding; New Eyes for Science; Vacuum Annealers ... 239
Have You Ever Thought About Silver? ... 35
Random Notes by the Editor ... 33
Synthesizing an Alloy to Order; Compounding of Metal Powders; Welding Rods and Electrodes; Weld Structure—a Correction 131
Where Do We Go From Here? .. 643

Fisher, Van
The Common Machine Bolt ... 761

Föppl, O.
Damping Capacity, Its Practical Importance ... 262

Froebel, G. H.
200-In. Telescope, World's Largest, Has Mounting of Welded Steel ... 132

Frost, E. R.
Rules Governing Forging Machine Dies; Data Sheet ... 416

Fuller, T. S.
New Copper Alloys, Age Hardened, Have High Conductivity 51

Gable, G. W., and others
Approximate Critical Temperatures for S.A.E. Steels ... 462

Gammeter, Elmer; Leon C. Bibber
The Status of Welding in 1937 .. 551

Genders, R. and R. Harrison
Tantalum Irons and Steels ... 56

Geen, C. P.
Breaking-In Copper-Lead Bearings ... 785

Gill, James P.
Classification of American Toolsteels; Data Sheets ...458, 459

Giolitti, Federico
Divergence of European Standards 164
Electric Pig Iron, Performance of Italian Shaft Furnaces ... 268
New Types of Refractories for Openhearths ... 384
Refractory Cast Irons ... 680

Goss, Norman P.
Microscopic Imperfections in Metallic Crystals ... 41

Gough, H. J.
Incipient Fracture Revealed by X-Rays; abstract of paper for International Association for Testing Materials ... 276

Greene, T. W.
Oxy-Acetylene Welded Pipe Joints —Scope, Utility and Economics 36

Grenell, L. H.
Controlled Hardening of Tools, the Steel ... 243

Gwyer, A. G. C. and S. L. Archbutt
Advances in Aluminum Alloys in England; abstract of papers for International Association for Testing Materials ... 286

Hamilton, W. C.
Note on the File Scratch Test .. 265

Harrison, R. and R. Genders
Tantalum Irons and Steels; summary of paper for British Iron and Steel Institute ... 56

Herschman, Harry K.
Microstructure of High Purity Iron-Carbon Alloys; Data Sheet 781

Hoyt, Samuel L.
Powder Metallurgy of Tungsten and Other Refractory Metals .. 749

Hughes, John Scott
Metal Yachts Race for the Cup.. 252

Hume-Rothery, William
Crystallography of the Elements, Groups I, II, III ... 490
Groups IV, V, VI ...57, 492
Groups VII and VIII 157, 494

Isenburger, Herbert R.
Exposure Chart for Radiography of Steel; Data Sheet ... 498

Iwaze and Okamoto
Nickel-Silicon Diagram ... 675

Jenkins, Francis G.
Copper-Lead Bearing Metals Favored for Severe Service ... 145

Jevons, J. D.
Directional Properties in Brass Strip ... 164

Jones, W. D. and Edward J. Daniels
Smooth, Non-Porous Coatings of Tin on Copper ... 256

Keller, F. and G. W. Wilcox
Identification of Constituents in Aluminum Alloys; Data Sheet 579

Kempf, L. W.
Tensile and Endurance Properties of Cast Al-Si Alloy ... 681

Landis, W. S.
High Grade Zinc Electrically Smelted ... 776

Lessells, John M.
New Aspects of Fatigue and Creep ... 257

Llewellyn, F. T.
Chart Classifying the Principal Welding Processes; Data Sheet 554

Loskiewicz, L.
67:33 Brass Sheet, Relationship Between Hardness and Tensile Properties ... 272

Maurer, E. and W. Bischof
Phosphorus Balance, Basic Steel to Slag; Data Sheet ... 438

McCloud, J. L.
Copper-Lead Bearing Metals, Some Points on Automotive Practice 267

Mikulas, William and L. A. Philipp
Modern Refrigeration Needs Modern Metallurgy ... 755

Monypenny, J. H. G.
Embrittlement of Steels at High Steam Temperatures ... 67
Trends in Alloy Steels in England ... 447

Moore, H. F.
Internal Fissures Induced in Rails by Soaking in Hydrogen ... 159

Morris, M. J. R., and others
Approximate Critical Temperatures for S.A.E. Steels ... 462

Neave, D. P. C. and Willi Claus
Lead Bronzes in England and Germany ... 149

Ness, Harold J.
Fine Dispersion of Lead in Copper Caused by Lithium ... 678

Okamoto and Iwaze
Nickel-Silicon Diagram ... 675

Palmer, F. R.
The A-B-C of Corrosion and Heat Resisting Steels; Data Sheet .. 524

Pearce, Charles S.
An Industry Comes of Age, Enamelers Meet in Open Forum ... 42

Peirce, W. M.
Ductile Zinc Coatings ... 679

Pelton, R. S.
Interrupted Spot Welding Uses Electron Tube Control ... 59

Peterson, O. N.
Heat Treatment and Metallurgical Control ... 337

Phelps, Stuart M.
Properties of Refractory Materials, Except Fireclay; Data Sheet 383

Philipp, L. A. and William Mikulas
Modern Refrigeration Needs Modern Metallurgy ... 755

Portevin, Albert M.
Erroneous Interpretations of Studies Under Polarized Light 63
Evolution of Gun Steel ... 783
Influence of Cold Work on Austenitic Grain Size ... 166
The Creusot Centenary ... 681

Raymond, Lloyd E.
Furnace Practices Improve Forgings ... 373

Reiter, Fred M.
Controlled Hardening of Tools, the Atmosphere ... 240

Rimbach, Richard and M. F. Behar
Instrumentation, Exact Science Combined With Fine Art ... 487

Rolf, Raymond L.
Welding of Cast Iron Discussed at Birmingham ... 777

Rosenberg, Samuel J.
Wear Testing ... 65

Samuels, M. L.
Voids in Graphitic Steels ... 167

Schneidewind, Richard
Electric Furnaces in the Foundry; Advantages and Disadvantages 665

Seemann, A. K.
Surface Hardening With the Oxy-Acetylene Flame ... 247

Sergeson, R., and others
Approximate Critical Temperatures for S.A.E. Steels ... 462

Sidery, A. J., and others
Fluxes for Soft Solder; abstract from *Journal* Institute of Metals 52

Simon, Richard W.
Advances in Carbon Steel Manufacture and Application ... 431

Sims, C. E.
Good and Bad Actions of Aluminum in Steel Castings ... 674

Sissener, John
Foundry Work on High Chromium-Iron Castings ... 521

Steever, Adam M.
Improvements in Forging Methods 413

Strauss, Jerome
Relative Corrodibility of Some Common Metals and Alloys; Data Sheet ... 526

Sutton, H., J. W. Willstrop and A. J. Sidery
Fluxes for Soft Solder; abstract from *Journal* Institute of Metals 52

Swinden, T. and G. R. Bolsover
Controlled Grain Size in Steel; abstract from *Journal* Iron and Steel Institute ... 174

Sykes, Wesley P.
Carbon-Free Alloys Hard as Toolsteel; Summary of Campbell Memorial Lecture ... 649

Tarasov, Peter P.
Improved Illumination for Microscopes ... 266

Thum, Ernest E.
Diversification of Stainless for Special Purposes ... 597
Preparation of Furnace Gases for Non-Oxidizing Atmospheres ... 377
Trends in Alloy Steels in America 463

Vaughan and Alexander
Nickel-Aluminum Diagram; Data Sheet ... 675

Walters, Francis M., Jr.
Nature of the Iron-Manganese System ... 254

Weiss, Myron
A Note on Production ... 784

Whiteley, John H.
Precise Control of Atmospheres Required to Prevent Surface Reactions ... 783

Wilcox, G. W. and F. Keller
Identification of Constituents in Aluminum Alloys; Data Sheet 579

Wilkinson, W. D., Jr.
Columbium in Steels, Plain Chromium and Chromium-Nickel ... 661

Williams, Robert S.
Metal Cans for Food; Abstract by Myron Weiss ... 660

Willstrop, J. W., A. J. Sidery, H. Sutton
Fluxes for Soft Solder; abstract from *Journal* Institute of Metals 52

METAL PROGRESS

VOL. 32 JULY, 1937 NO. 1

Front Covers

UNUSUAL circumstances conspired to prevent adequate credit being given in June METAL PROGRESS for the striking cover design. Apologies are therefore tendered to Edward G. Budd Mfg. Co. of Philadelphia for a poor recompense of their courtesy in loaning the art work. It was used in black and white by Budd some months ago on a handsome brochure describing the advantages of ultra light-weight construction in transport (air, water, rail and highway) when properly designed and shot-welded of stainless steel.

This month's cover is a photograph of the business end of an oxy-acetylene cutting machine, kindly lent by Air Reduction Co. It is a worthy addition to a series for which many congratulations have been received.

Other Types of Art

THAT such good subjects for pleasing and striking front covers are readily available is ample proof that artists are finding things in metal manufacturing worthy of recording on canvas, paper and film, and that sales and advertising managers of metal goods are spending some money for talent — thus creating publicity of a quality in keeping with the goods they are promoting.

This inherent quality is really amazing. The Editor, who recently saw some excellent metal work of various periods, was left breathless by the effects those old workers achieved merely in iron, brass and bronze. Combinations of polished iron and yellow brass, oxidized bronze and temper colors, were seemingly ample for those designers. How much richer the modern resources in alloys and fabrication methods!

Forthcoming Events

SOME glimpse of this may be had at the forthcoming ⊜ Metal Congress in Atlantic City, Oct. 18 to 22. The Auditorium (probably the largest open floor in the country, if not in the world) will be crowded to hold the exhibits, and eye appeal, as everyone knows, is the modern trend in exhibitions. The show, therefore, should set a new mark in size, interest and variety.

Technical, engineering and educational programs will combine to make it a full week. The Campbell Memorial Lecture will be given by Wesley P. Sykes. A carburizing symposium, stressing practical aspects of the problem, will occupy two days. Two lecture series, one on openhearth furnace practice and the other on metallographic technique will occupy late afternoon hours.

METAL PROGRESS' October issue will appear in a special edition prior to the convention and, as in the past, be subdivided into ten units each devoted to an important branch of the ⊜ field. An innovation will be the inclusion of many sheets of reference data. (By the way, did you note the index to Volume 31 on page 660-A of last month's issue?)

Next Spring

A SERIES of expositions and congresses held on the West Coast, interrupted by the late depression, will be resumed next spring. Successful Western Metal Shows were held in Los Angeles in 1929, and in San Francisco in 1931. Next year, the week of March 21 to 25 will see the third of these gatherings, this time repeating in Los Angeles. A well-designed program featuring the regional interests of the rapidly growing and enthusiastic members along the Pacific will clarify the metallurgical problems of the petroleum, aircraft, chemical and mining industries.

If you plan your vacation long enough ahead, then would be a good time to spend it on a leisurely ship via the Panama Canal. If you are in a hurry, you can make up for lost time by a dash back across country in the new high speed trains on the Santa Fe or Burlington.

Photo by Dana B. Merrill for Rogers, Lunt & Bowlen Co.

Unrivalled In Its Beauty, Silver Doubtless Has Many Commercial Potentialities

HAVE YOU EVER THOUGHT ABOUT SILVER?

Editorial Comment

MOST raw materials are tagged (in the mind of the average person) with the function of their outstanding property or major use. For instance, arsenic is a poison, sugar a sweetener, tin a lining for cans. Silver means money, on second thought tableware, and, if the person in question is educated along those lines, photography and bullion may suggest themselves. Until recently very minor additions to this list would actually have accounted for silver's usefulness. The prime utility is for monetary purposes, and it seems strange for an industry accounting for over $100,000,000 a year to be engaged in digging silver out of holes in the ground and then selling it to others who dig other holes and bury it again! Yet the Indian native, the Chinaman and the U. S. Treasury are joint sponsors for just that situation.

Freed of these traditional aspects, silver actually proves to be an industrial metal with striking properties. It stands in middle ground between the precious and the more common metals and many research laboratories are attempting to evaluate it in terms of particular problems. Silver stands unrivaled in thermal and electrical conductivity and optical reflectivity within the visual range; it is unattacked by organic acids or strong alkalis; it is exceedingly malleable and has a low coefficient of friction; it resists oxygen even at high temperature and the black sulphide tarnish it readily acquires is electrically conducting; it has marked bactericidal and fungicidal properties; many of its salts are photochemical. True, metallic silver costs about $7 a pound, but beryllium, tungsten and vanadium, to name but a few alloying materials in general use, are not cheap. The price is not so high nor the supply so limited as to exclude its industrial use in places where it is eminently fitted for specialized duty.

Some of this current research into uses for this neglected metal may suggest others to metallurgical readers of this article. In bacteriology, both university research and commercial exploitation are under way on industrial applications wherever it is desired to sterilize a medium or inhibit bacterial action, as in making swimming pools safe, in the manufacture of vinegar and the preservation of fruit juices. Its fungicidal properties, in relation to the rapid germination of seeds, are being investigated in agricultural schools.

In the engineering field the rather remarkable effects of replacing copper with silver in special electrical devices such as commutator faces is being explored. As an electrical contact material, either pure or alloyed, large and rapidly increasing quantities are being used; switch blades, circuit breakers and relays are widely equipped with silver alloy surfaces. Silver solders are in surprisingly common use; perhaps someone will devise a solder to fill the still large temperature gap between hard and soft solders, or one to join the 18-8 type of stainless steels at temperatures below the "susceptible" zone. Cadmium-silver bearings are an old story, and bearings of fine silver are now being experimented with, because in addition to a low coefficient of friction and high thermal conductivity, silver does not readily gall or seize against steel. Duplex metal and plate — silver on either copper or iron — is now available in large sizes and the technique has been worked out for welding joints in both faces; this should facilitate the use of silver-lined apparatus in chemical industry. Silver powder and even bimetallic powders add interest to that new branch of technology.

Of the various salts of silver the sulphide has remarkable properties. It is a plastic and can be melted, cast, rolled, drawn and soldered. It is a complex electrical conductor with a large temperature coefficient and certain rectifying properties. Surely someone can find a use for this strange combination of qualities in the electrical, radio or electroplating fields.

Of the silver-rich alloys, the dental amalgams have long been of great importance. Some progress is now being made in the hardening of silver by small additions of other metals. Non-tarnishing silver has also been studied for years. The earlier investigations were almost wholly on the sterling grade, whereas now fine silver itself with small additions is under investigation.

In silver-poor alloys the field is limitless and many systematic investigations are under way. Silver helps wrought copper by raising its annealing temperature; in certain binary alloys it reduces brittleness; the whole lead-silver series is remarkably corrosion resistant. An extensive series of low silver ternary alloys is being prepared at the Bureau of Standards; many of them are quite new and may reveal unexpected qualities, useful in unexpected places. This whole program should be watched by alert ⊕ members.

OXY-ACETYLENE WELDED PIPE JOINTS—SCOPE, UTILITY AND ECONOMICS

By T. W. Greene
Engineer, Development Section
The Linde Air Products Co.
New York City

BECAUSE the utility of a piping system depends so largely on the character of its connections, welding has always commanded wide attention. This is because welding alone, of all constructional methods, makes possible what is for all practical purposes a *jointless* system. No other method gives the designer as much freedom in disposing the pipe as he wishes. Because it is so highly adaptable and widely successful in all phases of pipe fabrication and erection, oxy-acetylene welding commands particular attention in any discussion of advancements which make piping a better servant of industry.

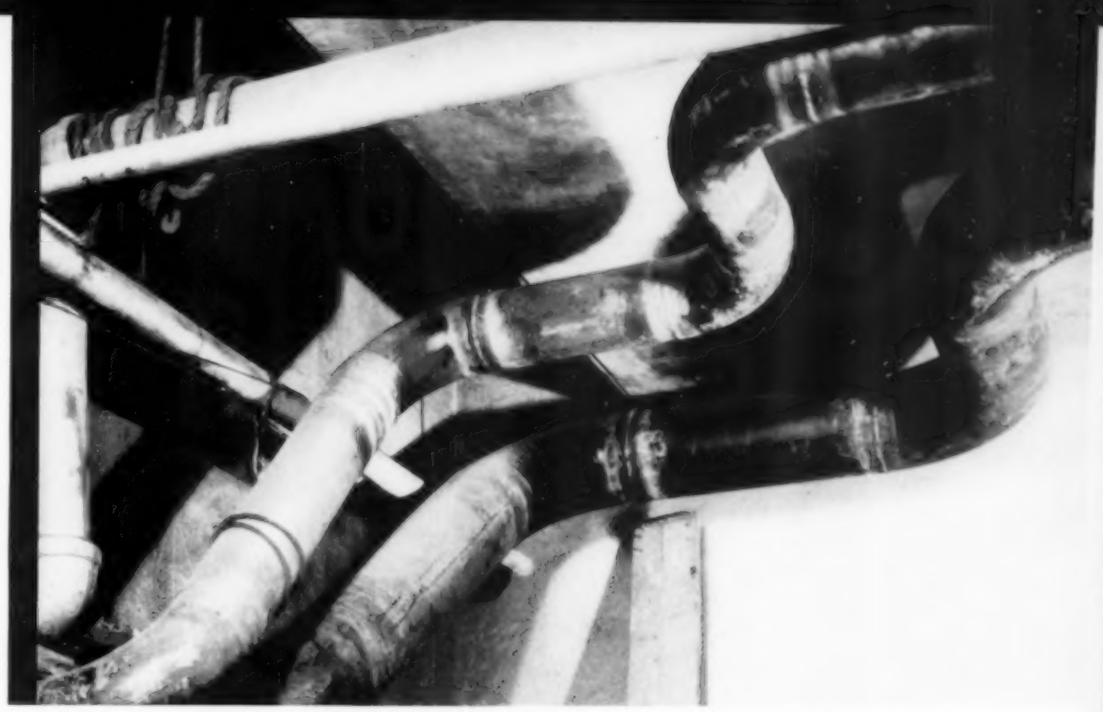
Scope of Pipe Welding. To appreciate more fully the significance of the newer developments and trends in the gas welding of pipe joints, it is only natural to want to know (1) what piping services are now customarily welded, (2) for what pressures and temperatures welded joints are being used, and (3) what pipe materials are being satisfactorily welded.

As to scope, the more important industrial and building jobs are today almost invariably welded. Steel or iron pipe is customarily used for the services, which include steam, water, air, oil, gas, refrigeration, air conditioning, and process piping. Steam piping in a large number of Government buildings in recent years has been welded, and the same applies to a majority of skyscrapers erected in the last 10 years.

Welded heating installations are of course not limited to the larger buildings. Some contractors make a specialty of smaller buildings and find it practical to weld *all* pipe sizes.

Underground steam mains — especially those laid under city streets from central heating plants — are invariably welded because of the particular necessity for permanent joints in inaccessible places. Even the valves and expansion joints are welded directly to the pipe, so as to reduce maintenance expense to an absolute minimum. Power plant piping is customarily welded, a significant number of high pressure, high temperature welded installations having been made in recent years (see particularly the article by R. M. Van Duzer, Jr., in last month's METAL PROGRESS). High pressure steam lines 16 in. in diameter with a wall thickness of $1\frac{1}{2}$ in. have been satisfactorily welded.

New piping installations in petroleum refineries and gasoline plants are also largely welded. Due to the nature of the materials conveyed, it is frequently the practice to provide mechanical joints at points where it may be necessary to disconnect piping for inspection or cleaning.



Freed From All Unnecessary Weight and Bulk, These Welded Lines Have Just What It Takes for Years of Maintenance-Free Service

Service Pressures and Pipe Materials

For the past ten years, the welded joint has predominated in the field of overland pipe lines for gas, gasoline, and oil. This is true also of gas distribution systems using steel pipe. Steel water lines are customarily welded, and a number of cast iron pipe lines have been laid where every other joint or every two out of three joints have been bronze-welded.

As far as the metals most commonly welded are concerned, the only limit as to temperatures or pressures is that of the pipe itself; 100% strength is readily obtainable with the standard welded line joint. For branches, turns, and similar connections, fittings of suitable strength are almost always available for welding into the system, or they can be fabricated on the job.

Thousands of miles of oil and gasoline lines are in daily operation at pressures around 800 psi. Many welded hydraulic lines are in service operating at over 3000 psi. pressure, and there are welded power plant piping systems operating at pressures over 1000 psi. and at temperatures of 800 to 900° F.

Materials. Since the most suitable metal should be obtained for a particular service, the various ferrous and non-ferrous alloys are extensively used.

Pipe of special ferrous metals (such as stainless steel and 4 to 6% chromium steel) is satisfactorily fabricated and installed by fusion welding. Depending upon the severity of service, special welding rods and procedures may be required.

Pipe made of non-ferrous metal (such as brass, copper, aluminum, lead, nickel and monel) is found in special services where welding would quite naturally be the best method for making the joints. As an indication of pipe sizes welded in the non-ferrous materials, brass lines ranging up to 12 in. in diameter were bronze-welded in the air conditioning system in a large New York building constructed several years ago. There is no reason to think that this is the top limit.

Galvanized pipe is not as commonly welded as plain steel and iron pipe, yet a considerable amount of it has been installed by fusion or bronze welding without any evident shortening of the life of the pipe. Bronze welding has the least effect on the galvanizing.

Wall Thicknesses. The designer working with high pressure piping or long pipe lines has in the past had a reasonably wide choice of pipe wall thicknesses to meet his particular needs. Not so, however, the designer working with piping to operate up to 200 or 300 psi. pressure at normal temperatures — he has had to use standard weight pipe, the wall thickness of which is based on requirements for threading, even though this thickness might be double that required for the service.

Piping systems of all sorts and of many metals are constantly being welded by the oxy-acetylene process, the principal limitations coming from the properties of the pipe itself. The new back-handed technique for steel, using multi-flame blowpipes, excess acetylene, and low alloy filler rods, cuts the time to one-third and improves the quality of the work

Oxy-Acetylene Welds Are Readily Made Overhead With the Same High Quality That Characterizes Other Positions of Welding

Now, however, it seems there is to be some measure of relief for such lower pressure systems. New tentative standards for steel and wrought iron pipe, introduced by American Standards Association in 1935, allow for ¼-in. wall pipe in the 8, 10 and 12-in. sizes. Although unsuited for threaded joints, pipe of this weight is of course even more readily welded than the thicker, standard weight pipe.

Compared with the old standard, the weight saved in the 12-in. size amounts to 33%; in the 10-in. size 30%; and in the 8-in. size 22%. The 8-in., ¼-in. wall lap-welded pipe will be suitable up to 270-psi. steam service pressure, at temperatures not exceeding 450° F. Since welded joints are of full wall thickness, the overall life of the thinner wall pipe in mildly corrosive service should still match, if not exceed, the life of standard weight pipe at the threaded ends.

Safe Construction Code

When the A.S.M.E. Boiler Code was liberalized some years ago in respect to fusion welding of boilers and pressure vessels, the use of welding in this field soon advanced to a remarkable extent. With the adoption in 1935 of the new Tentative Code for Pressure Piping, sponsored by the American Society of Mechanical Engineers, no such proportional increase in the welding of pressure piping is expected. This is because a great deal of such work has been done despite the absence of a safety code.

Nevertheless the new Code will be of considerable help to those who have felt hesitant about welding the more hazardous services. The Code represents a standard of minimum requirement for materials, dimensions, design, erection, and testing of completed systems. It treats welding in detail and permits its use for all temperatures and pressures to which the pipe being used is suited.

Necessity for checking through the conflicting information of several dozen technical articles and manufacturers' catalogs is never conducive to the wide acceptance of a new construction method. Engineers interested in pipe welding need not do this. A detailed manual on fabrication and erection has been available now for some years, and just recently a very complete manual on design has been published. With the aid of these the piping designer can become as well equipped to utilize welding fully as is the engineer who has kept constantly in touch with current developments.

New Speed and Quality in Welding

Certainly the most important pipe welding developments in recent years have been the oxy-acetylene welding methods which employ the excess acetylene flame and special backhand welding techniques. Metallurgical aspects of this revised process have been adequately described in several issues of METAL PROGRESS, most recently by J. H. Critchett in January 1935. These new methods have increased welding speeds as much as four times over what was formerly possible, and at the same time they have brought about considerable improvement in weld quality. It is puzzling, therefore, to know that they have been used to such a relatively small extent for industrial piping as compared to overland pipe line construction.

Within a year after the introduction of the new methods in 1930, a great majority of the oxy-acetylene welded pipe lines under construction were employing the new technique. Yet seven years later it certainly cannot be said that anywhere near one-half of the oxy-acetylene welding in the building and industrial field is so done. Probably the biggest factor in holding back its more general adoption is simply inertia — both on the part of the operators who do the welding and those for whom they work.

It is relatively easy to learn to weld by the new method, although it does, initially, require instruction from an operator thoroughly experienced in it. Operators commencing to use this new method will find the ¼-in. wall pipe in the 8, 10 and 12-in. sizes much easier to weld than the standard weight pipe. Thus the newer pipe weights may prove to be a factor in bringing this admittedly better and more economical welding method into increased use.

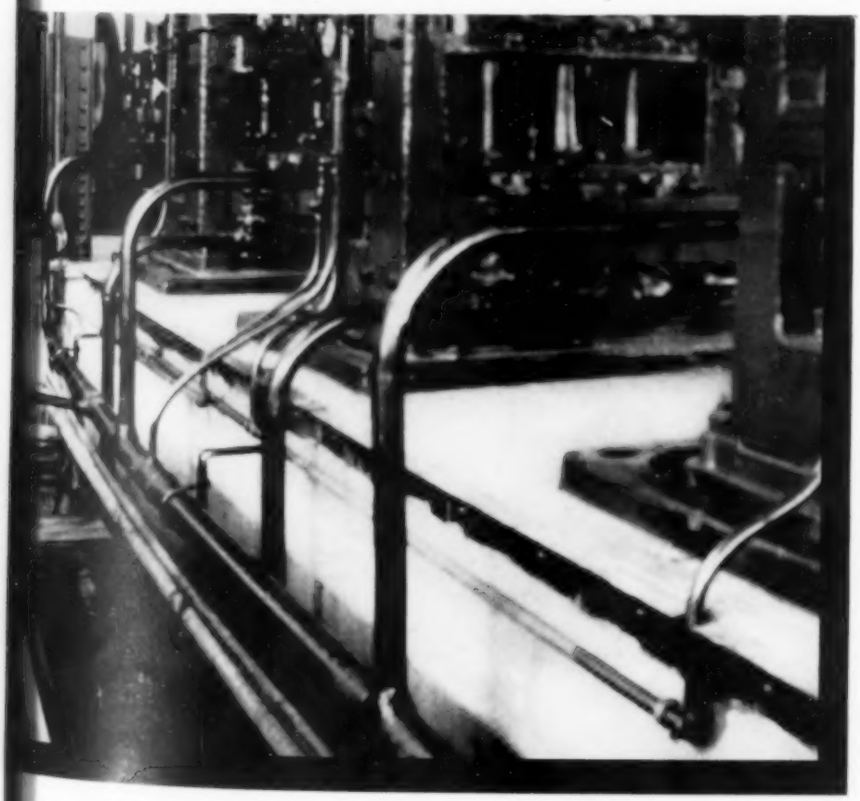
The fastest welding speeds with the new method are made with multi-flame heads which preheat the vee ahead of the puddle, thus warranting a narrower vee and less rod and flame manipulation.

In much of the overland pipe line construction, especially the shorter lines, every weld is made overhead — that is, in position, without turning the pipe. It has been found that operators thoroughly experienced with the new oxy-acetylene method can make position or overhead welds almost as rapidly as they can make roll welds, and since there are many advantages in not moving the pipe, this method promises still lower welding costs for many types of lines. The same holds true in the building and industrial field, when operators are available who are thoroughly experienced in the new method.

A comparison of welding speeds will show interesting economies for industrial piping. In welding 6-in. standard pipe, the average operator will take about 21 min. for a roll weld, using the older method. After brief training in the new technique, he should weld the same joint in about 9 min., and if he were trained to use a multi-flame welding tip and did nothing but weld 6-in. joints all day long, he should make this same weld in about 6½ min. With things working smoothly out on a cross-country pipe line, he would be expected to make about 60 of these 6-in. welds a day. Corresponding times for 10-in. pipe are 41 min. for the conventional system, 20 min. for the beginner in the new technique and 10½ min. for well organized field work. Forty 10-in. welds would be expected per operator in an 8-hr. day in overland pipe line construction.

Admittedly, weld production like this can never be hoped for on an industrial job where operators must work in awkward positions and where there are many other hindrances to a steady flow of work. Still, these marks made on overland pipe lines are something to shoot at. When oxy-acetylene welding is done as efficiently and as rapidly as is now possible, the actual cost of welding becomes a really negligible part of the final cost of the pipe in place.

Water Under 3500-Psi. Pressure Is Carried by the 4-In. Line Shown Here With Welded Branch Connections. Oxy-acetylene welding knows no limit in pressure



Welding in Layers

Pipe with heavy wall is also handled somewhat differently with this new method. Practice had been to make the weld in a single pass or layer if at all possible so that it would not be necessary to go around the pipe more than once. This worked out fairly well with the older method, although pipe thicker than ¾ in. was usually welded with a modified layer technique.

With the newer method

it is becoming the practice to put the weld on in two or more layers when the metal is more than ½ in. thick. This does not increase the cost of the welding to any extent, because the greater ease and rapidity of welding in thinner layers makes up for the greater linear distance of travel.

Such welds are made in two or more layers, either by going completely around the pipe for each layer or by making the layers in steps. With the step method, the operator welds 3 to 6 in., goes back and welds the second layer over the first, and then keeps right on going another 6 in. past the first weld. He then goes back to the end of the completed weld, builds up the final layer, and so on.

In any discussion of the newer oxy-acetylene welding method, it should be mentioned that it is even easier to do a thorough job at the bottom of the vee than formerly, without the aid of any liner or sleeve. A liner or sleeve is not needed to keep metal from dripping inside the joint. In the construction of oil pipe lines, for instance, any metal protruding inside would obstruct the passage of the "go-devil" or scraper sent through periodically to loosen paraffin from the walls of the pipe. The fact that thousands of miles of oil pipe lines have been welded with newer oxy-acetylene method is indication enough that welds are regularly made on a production basis without fear of excessive protrusions.

Layout and Erection Problems

In the discussion of underground steam lines, it was mentioned that valves and expansion joints were frequently welded directly to the pipe in order to eliminate every possible mechanical joint. This is good practice in the installation of power plant piping generally, where the selection of suitable flanges and bolts has always been a problem. Actually, it is justified wherever a valve with a steel body would be used, because for every such valve welded into a line, a pair of flanges and the necessary bolts are eliminated; and in any event the companion flanges would have to be welded into the line.

The compactness and freedom from maintenance possible with this type of construction is being recognized by many piping designers who are assured by maintenance men that if a valve ever needs to be removed from the line, it will be just as easy to cut it out with the blowpipe and replace it by welding as it is to unbolt and then bolt it up again.

Important advancements have been made in welding fittings — "welding fittings" being the general term for fittings such as tees, reducers and elbows manufactured especially for welding into piping systems. A wide variety of these are available in steel and iron, except for the very large diameters and highest pressures. Complicated piping systems can, with their help, be readily assembled by welding in the field with the assurance that every part will have a strength equal to that of the pipe itself.

Some manufacturers supply welding fittings made of the various other metals commonly

Multi-Flame Welding by the Newer Oxy-Acetylene Method on a 12-In. Cross-Country Oil Line. The pipe wall thickness was ¾ in., and it took no more than 12½ min. to weld this joint.

used for pipe, such as brass, copper, stainless steel and aluminum.

To a much greater extent than formerly, designers of piping systems are laying them out for welding, and are not simply substituting welds for flanges or couplings in conventional layouts. There is so much more to be gained by taking full advantage of the possibilities of welding that it is difficult to see why this has not been commoner practice.

As has been shown on many important jobs, welded piping reaches the highest state of perfection where the system is designed and laid out for welding, where unit sections are detailed and shop fabricated and then erected by welding in the field — just as the structural framework for a large building would be shop fabricated and erected. This is an advancement over the old time cut-and-fit methods of piping installation that is indeed well worthy of careful study by all responsible parties. It will return golden dividends.

MICROSCOPIC IMPERFECTIONS IN METALLIC CRYSTALS

By Norman P. Goss
Metallurgist, Cold Metal Process Co.
Youngstown, Ohio

THE BELIEF that single crystals are actually built of smaller units has long existed. Haüy in 1801 studied the cleavage of crystals and was convinced that they were built of smaller units. It is worth mentioning that he was one of the first to conceive that crystals were built of atoms, but did not know that they were arranged on space lattices, for the microscope and X-ray were unknown at that time.

The classical theory of crystal structure was gradually developed, and reached its climax with Schoenfliess in 1891. His theoretical work, purely mathematical in character, showed that there are only 230 "space groups" and 32 "point groups" possible. This theory was developed entirely from external characteristics of crystals as found in nature. Laue suggested in 1912 that a crystal could be used as a three-dimensional lattice grating; experimental proof of the theory of space groups was thus possible.

Laue based his idea on the work of the great mineralogist Bravais, who in 1850 had postulated that the atoms in a crystal were arranged on a space lattice with more or less regularity.

Laue's discovery merged two great sciences together, the physics of X-rays and crystallography of matter, into a newer one of even greater possibilities. During this epoch the X-ray analyst assumed crystals to be homogeneous and free of imperfections, and such an assumption was perfectly valid from a classical point of view.

However, in the year 1922 C. G. Darwin discovered that when he reflected a beam of X-rays from the faces of some crystals, an unexpected increase in the *integrated* X-ray energy occurred. This could be explained if we consider the surface of the crystal to consist of small "blocks," whose faces are slightly displaced from each other. Calculation showed the angular deviation, "block" face to "block" face, to be only a few seconds. One must remember that Darwin thought he was using a *perfect* crystal, picked by careful selection, only to discover it to be imperfect. Such structures (imperfect) are oftentimes referred to as mosaic, lineages, veining, or groups.

As indicated in the abstract of Mr. Northcott's paper (METAL PROGRESS for February, page 152), this is of the greatest importance to metallurgists. These imperfections are not at all accidental, but are natural inherent characteristics, and must be regarded as such. The theory is now in the state of development, and since it is, many different ideas have been held during the past 15 years.

Zwicky's theory was perhaps the first; the others were more or less inspired by his ideas. Essentially he considered all crystals to be mosaic. The "blocks" of the mosaic have the normal lattice dimensions in their interior, but as the surface layers are approached the lattice spacings contract. Such a crystal (mosaic) was believed more stable than the ideal crystal.

Goetz made a significant discovery when studying single crystals of bismuth. He found that the characteristics depended on the degree of superheat above the melting point. He believed, therefore, that "before entering the solid state in crystalline form a metal has to go through a para-crystalline *(Cont. on page 80)*

AN INDUSTRY COMES OF AGE

ENAMELERS MEET

IN OPEN FORUM

By Charles S. Pearce
Washington, D. C.

WHEN the many and diverse interests which are engaged in the manufacture of any product meet to consider steps to improve that product, it may be assumed that such an industry has reached a state of maturity. When competitive organizations lay aside their antagonistic thoughts for a few days and join in a program of scientific promotion for the good of the industry, that industry has come of age. This is the principal remembrance of a gathering at the University of Illinois in May, when 148 representatives of concerns interested in porcelain enamel met for scientific and practical discussion. This first meeting of the Porcelain Enamel Institute Forum was planned as a substitute for various enamel training schools, short courses and enamelers' meetings, and it outdid all these activities in numbers present and in the scope and importance of work discussed.

All manufacturers of enameling sheets were represented at the meeting. In keeping with the technical character of the sessions, these companies were represented by their technical men — metallurgists, chemists, and members of their service staff. Their presence was especially welcome to those who are alive to the necessity of a good iron or steel foundation for enamel ware. What the trade knows as "enameling sheet" is really a special steel, and in boom times — which we are apparently approaching — there is a great temptation for the steel producer to occupy his available plant with more easily made tonnage steels. The present reporter believes that the importance of the enameling industry should be sufficient to halt such a trend; dearly won information on the manufacture of this specialty should not be lightly discarded.

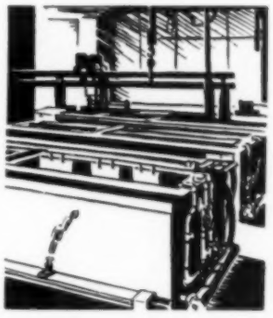
Requirements of the Base

Of prime importance to steel makers was the discussion of the metallurgical aspects of enameling. This covered not only the chemical composition of cast iron and steel sheet, but the physical properties that are necessary in these two materials for this purpose.

A paper by E. C. Greenstreet of Standard Gas Equipment Co. stressed proper design and fabrication of stove parts as well as enamel application. His discussion dwelt upon the cause of "hairlines" in enamel and suggested means to prevent them. Uneven heating is commonly responsible.

To avoid this several rules of design were mentioned, such as the danger of excessive

stretching of the metal in the drawing dies. Such stretching produces a very thin metal which heats locally more rapidly than the balance of the piece. Such regions are easily seen by the inspector. By the same reasoning double thicknesses of metal are to be avoided. Cutouts and holes which create flue effects in the furnace may also cause uneven heating and warping. Faulty dies often produce excess metal in the surface of rim-bound pieces, giving an "oil can" effect. This loose metal causes the enamel to craze and hairline.



Deep drawing stock should be used where difficulty in drawing is encountered. Annealing may help in some cases, but should not be considered a regular operation. In other words, pieces should be properly fabricated of proper metal before an attempt is made to enamel them.

Cast iron for enameling was discussed by M. L. Carl, foundry engineer for Sloss-Sheffield Steel and Iron Co. Mr. Carl said that irons of a wide variety could be enameled if care was taken in making the castings. Here again, designs should avoid unequal sections so that heating will be uniform. Cupola practice must be arranged especially for enameling castings. Not over 80% of capacity should be melted and small pigs should be used. Scrap should be kept low and no steel alloys used. M. E. Manson of Chicago Vitreous Enamel Product Co. attributed some of the blistering in enameling to iron melted with a low coke bed. He emphasized the necessity of proper sizing of coke.

The requirements of porcelain enamel for architectural purposes were brought up by Milton Gallup of Enamel Products Co., who stressed especially the design and fabrication of parts for this purpose. He gave a few good suggestions — of which the steel man should be aware, as they show the limitations of sheet iron for this use. Areas should be kept as small as possible, preferably not over 21 x 36 in. Good layout and accurate dimensions are essential, as field alterations are almost impossible. Wavy panels are one of the principal criticisms of architectural enamel. This brings in Mr. Gallup's most important suggestion — "Use the proper gage of sheet." Too many attempts have been made to economize on metal. Steel manufacturers will do well to assist in the development of the most economical gages for various shapes and sizes.

F. L. Michael of General Electric Co., in presenting data on the construction of a one-piece refrigerator cabinet, showed that this development was dependent on the use of steel that would not sag or warp at enameling temperatures. He recommended the use of standard tests for the sagging of sheet steels, such tests to be applied to every shipment of metal. These tests would eliminate unsatisfactory stock at the source.

Pickling of steel shapes, especially with relation to the manufacture of kitchen ware, was discussed by B. T. Sweely of Chicago Vitreous Enamel Product Co. This subject has been the source of much argument, but only a limited amount of actual research. It should be considered by the steel maker, as it is as much his problem as the enameler's. In the manufacture of gray kitchen ware a phenomenon called mottling occurs due to the rusting of the iron. This factor was discussed by E. C. Dexheimer of National Stamping & Enameling Co. To properly produce such ware, the drying of the dipped shape must be kept under close control, and humidity in the oven must be properly regulated.

Requirements of the Enamel

In the field of enamel requirements, a paper by W. N. Harrison of the National Bureau of Standards presented tentative standard tests for acid resistance. These tests are urgently needed as a basis for purchase specifications; they will do much to eliminate the phrase "the juice of a normally ripe lemon" from tests which are now used by purchasing agents of the Government as well as private industry. Mr. Harrison's proposals cover precise technical tests for acid resistance and set up five classifications of enamels under these tests. These tentative standards have been published by the Porcelain Enamel Institute (Chicago), and are available to all interested parties.

G. H. McIntyre of Ferro Enamel Corp. gave a thorough analysis of the various tests for durability of enamels applied to hollow ware. Metallurgists should note the results of a more intensive study of this field, as the use of iron as a base for kitchen ware has suffered severe

setbacks in recent years. Proper gages of metal will do much to remedy this situation.

Various phases of plant operation were discussed by foremen and supervisors. As this was a technical meeting it was fitting that plant operating men should have a large part in the program. Papers were therefore presented by men representing five of the largest producers in the country, but curiously enough, three were refrigerator and stove manufacturers. Some of these points had to do with the milling of enamels and as such are somewhat aside from the field of METAL PROGRESS.

However, W. H. Pfeiffer of Frigidaire Corp. proposed many improvements in plant operation in his talk on "Enamel Shop Housekeeping." The principal suggestion was air conditioning with enough clean air supplied at a positive pressure. This would absolutely eliminate defects due to the deposition of outside dust on the ware.

Danger From Metallic Dust

Floating dust and metal particles create problems of much concern to all enamelers. Metallic dusts will float for long distances and will almost invariably cause trouble, usually in the nature of that elusive enamel defect known as "black specks" (although metal dust may produce a definite blister). Humidity control is important, especially as it determines the rusting of iron shapes. Acid fumes from adjacent operations such as chromium plating may also be objectionable, as they contaminate the iron and etch the enamels. They must be studied from a metallurgical standpoint as well as from the hygienic. Various methods of compelling or encouraging personal cleanliness of shop operators and laboratory technicians were also mentioned.

"Factors Affecting the Efficiency of Spraying Operations" was the title of a discussion by Wesley G. Martin of A. O. Smith Corp. Especially interesting were the measures introduced to prevent operators from breathing enamel dust. Efficient spray booths prove to be much more desirable than the use of respirators or masks. Where some type of face protection and breathing apparatus is necessary the mask with a supply of washed air at positive pressure is the preferred type.

The most encouraging part of Mr. Martin's paper was his recognition of the part that selection and training play in the production of properly sprayed work. He emphasized the necessity of continuously training men to produce better work. He also recognized the factor of fatigue in affecting the proper operation of a spray gun.

One-Cover Coat Ware

Herman L. Cook of the Norge Division, Borg-Warner Corp., reported on his study of the production of one-cover coat ware. Summarizing replies to a questionnaire on this subject, addressed to various operating men, we find that the saving in cost of the additional coat of enamel is forcing this process on the industry, and in many places which are not ready for it. Quality usually must compare favorably with work produced in two color-coats, and only under the most favorable conditions is this possible. Design of parts must adhere to the very best standards and metal cleaning must be nearly perfect (either nickel flashing or cyanide pickling is recommended). This process cannot possibly be successful unless the enameling iron is free from many of the defects that would be acceptable where two coat work is done. Re-boiling of ground coat due to faulty metal or to bad cleaning may defeat the process completely.

In general, the successful application of enamels in one-cover coat waits on two improvements: A super-opaque enamel with good workability and an enameling iron free from such defects as re-boiling, tendency to copperhead, and excessive warping.

"Enamel Shop Production Problems" was the title of a paper by Jay B. Simons of Westinghouse Electric & Mfg. Co. Mr. Simons asked for sound welds, both gas and spot, and clean metal before starting the enameling process. He especially stressed the necessity of properly cleaning the metal before welding so that sound welds would result. Pickling by various continuous processes was discussed. Proper handling equipment is essential. Facilities for color matching parts must be provided. Schedules of parts must be kept in balance and rework should be cleaned up hourly.

Radiant Tube Furnaces

New developments in furnaces were presented in a report by F. S. Markert of the Ferro Enamel Corp. The small continuous furnace with a capacity equal to approximately two box

furnaces is the most outstanding development in design in the past few years. No other improvements along general lines were mentioned, but there is a tendency to design the larger production units to handle larger pieces of ware.

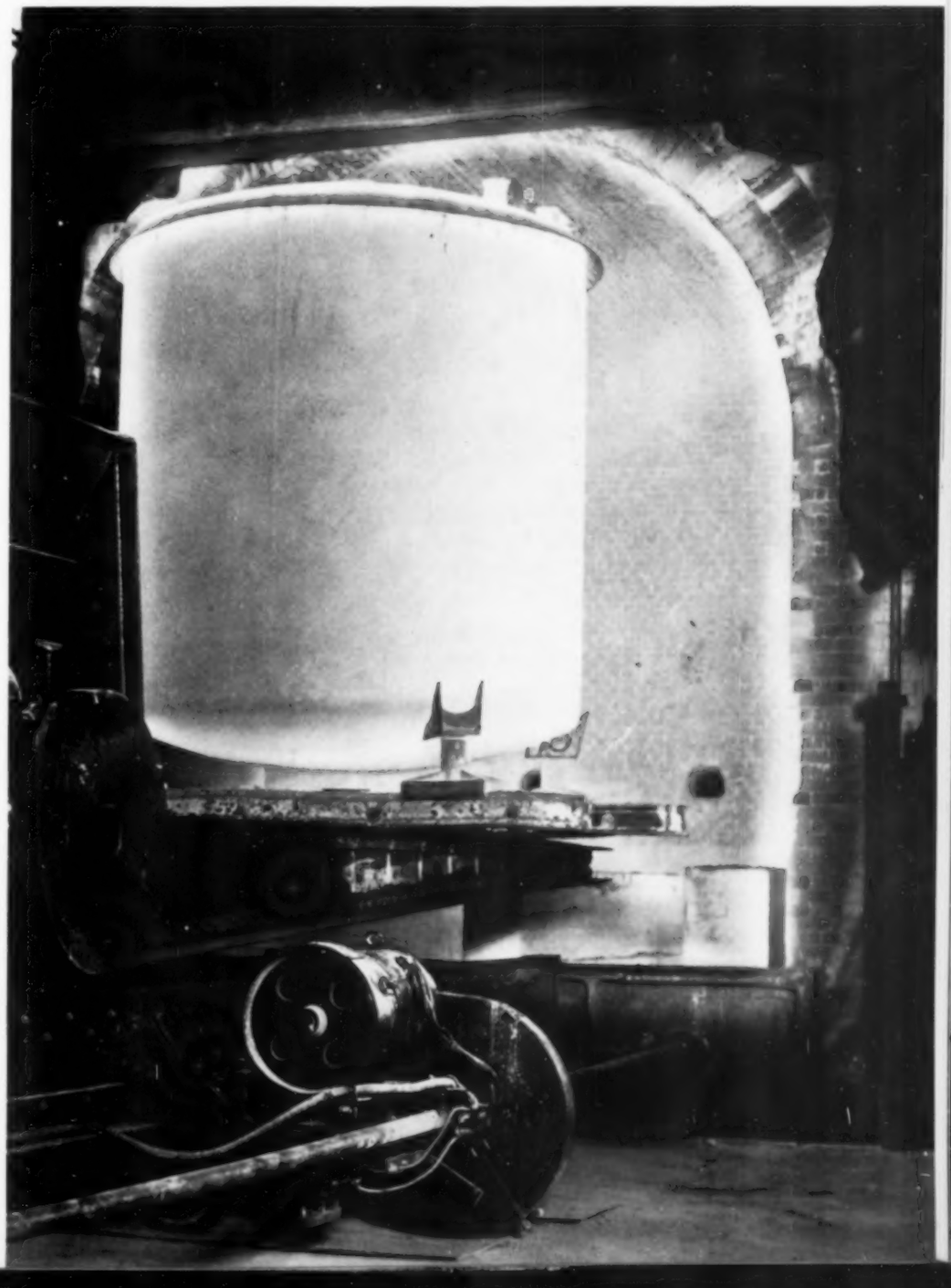
The introduction of the radiant tube method of heating is the latest development in design; it may well revolutionize fuel fired furnaces. A furnace heated in this way was illustrated on page 393 of the April issue, METAL PROGRESS. Radiant tubes are made of comparatively cheap alloys which will withstand temperatures up to 2000° F. Standard nickel-chromium-iron alloys are used and very few failures have been noted. This method of heat transfer has already been extensively used in heat treating furnaces, and has been described properly in these columns. It is particularly adaptable to enamel manufacture due to the method of firing under negative pressure. Almost perfect combustion is thereby secured and combustion products cannot enter the enameling chamber.

The use of radiant tubes, while affording a new use for high alloys, may also cause radical changes in design and insulation of furnaces to provide the volume of heat necessary to secure quick "come-back" with cold ware. In the discussion it developed that, theoretically, tubes of 85 to 90 ft. could be used although practical applications called for much shorter tubes. Heat transfer is almost equivalent to that of electrical ribbons and can be figured on about the same basis. Life is estimated to be at least four years.

There were other subjects of a non-technical character discussed. E. L. Lasier of Titanium Alloy Mfg. Co., and chairman of the Institute's Educational Bureau, said that the Bureau would spend $53,000 this year for development work. This amount for a relatively small industry that employs approximately 10,000 men compares most favorably with the expendiures for technical advancement by any trade association.

This meeting marks the end of the period of rule-of-thumb methods in the porcelain enamel industry, and the beginning of the application of collective scientific thought to technical problems. As this industry matures, more use will be found for the ideas and thoughts of the ceramist, the chemist and the metallurgical engineer, to the ultimate advantage of the consuming public.

Enameled Ware Includes Not Only Stoves and Sanitary Equipment, Utensils and High Class Cabinets of Sheet Metal, But Also Can Run to Very Large Pots for the Process Industries. Photo courtesy The Pfaudler Co.



ARC WELDING CONTINUALLY ADVANCES IN PIPE LINE CONSTRUCTION

By Alton F. Davis,
Vice-President
The Lincoln Electric Co.
Cleveland, Ohio

THE MOST MODERN development in construction of pipe lines for overland transportation of crude oil is the use of plain butt joints (without inside backing-up ring) on pipe with straight ends. This joint, replacing the double bell joint made with a backing-up ring, is the simplest possible type for pipe line construction, and is now used almost exclusively in the arc welding of oil pipe lines.

The pipe ends (which have been bevelled usually to about 30°), are lined up with a space of about $\frac{1}{16}$ in. between them and tack-welded together. These tack welds are usually between one and two inches long and two or three of them are used per joint, depending on the size of the pipe. Tacking is done with $\frac{1}{4}$-in. or $\frac{5}{16}$-in. electrodes. Final welding of the joint then begins. If the wall is $\frac{13}{64}$ to $\frac{5}{16}$ in. thick — a range covering most of this type of construction — this is done in three beads, or passes, as the pipe is turned, each bead being cleaned before application of the next. The first, or stringer bead, seals the bottom of the vee and is made with $\frac{3}{16}$-in. electrodes. The size electrode used for the second bead (which bottoms on the stringer bead and builds to the outer surface of the pipe along one edge of the vee) is $\frac{1}{4}$-in. or $\frac{5}{16}$-in. depending on the pipe size. Either $\frac{5}{16}$ or $\frac{3}{8}$-in. rods are used for the third, or finish bead, which matches the second bead along the other edge of the vee.

Speeds for welding plain butt joints without backing-up ring on various sizes of pipe most widely used in oil lines are as follows: 6-in. pipe, 5 welds per hr.; 8-in. pipe, $4\frac{1}{2}$ welds per hr.; 10-in. pipe, 4 welds per hr.; 12-in. pipe, $3\frac{1}{2}$ welds per hr. Larger sizes — 14 and 16 in., using plain butt joints without backing-up ring — have been welded with the electric arc at the rate of 30 and 26 joints respectively per man per 9-hr. day. Speeds given above are conservative and apply to welding under generally favorable conditions, as is indicated by the fact that they have been exceeded on many lines.

Savings in construction costs through the use of plain butt joints, arc-welded without backing-up rings, are large. The former type of joint (the double bell with backing-up ring) was more costly for two principal reasons: In the first place all pipe ends had to be belled, costing approximately $1.50 per ton of pipe. In the second place, backing-up rings cost 25 to 35¢ each. Since a 40-ft. length of average sized pipe weighs about half a ton, the cost of such a joint was $1.00 to $1.10, over and above the welding cost. This expense is eliminated when plain butt joints are used, since no belling nor backing-up rings are needed.

In the construction of gas pipe lines of larger diameter, however, the type of joint used is the plain butt joint with a backing-up ring. This joint is permissible since the backing-up ring inside the pipe, being of minor thickness

compared with the large pipe, offers small resistance to the flow of gas. This type of joint is ordinarily welded in two beads, the first a stringer bead, the second the finish bead. The first bead which seals the bottom of the vee is welded with $\frac{1}{4}$ or $\frac{5}{16}$-in. electrodes; the second with $\frac{5}{16}$ or $\frac{3}{8}$-in. electrodes completes the joint. Such joints are welded on the "firing line" at approximately the following speeds (which are based on average speeds obtained in welding a large number of lines): 16-in. pipe, 2.9 welds per hr.; 18-in. pipe, 2.6 welds per hr.; 20-in. pipe, 2.3 welds per hr.; 24-in. pipe, 1.6 welds per hr.

Standard Pipe Line Procedure

Pipe for oil or gas lines is lined up in sections. The number of pipe lengths in each section varies according to the length and diameter of the pipe and the nature of the terrain. The sections are lined up on rollers so that they can be turned beneath the arc when welding the joints, several of which are made simultaneously. This part of the work is known as the firing line. After a section is completely welded in this manner it is placed over the trench (if not already there) and welded into the previously completed portion. Since it is impossible to turn the section when welding it into the lines, it is necessary to make a joint around the pipe in a fixed position. This operation is known as "bell-hole welding."

Following bell-hole welding, a portion of the line is placed in the ditch, usually about nine lengths, and the ditch backfilled to hold slack, leaving three joints out of the ditch on skids. The part on skids is usually left until sometime before dawn, when contraction is maximum, at which time the supports are pulled aside, the pipe crowded into the ditch and covered. This procedure prevents excessive contraction of the line after the ditch is backfilled.

In making river crossings the pipe is welded up in a section long enough to span from bank to bank. Such a section might measure as much as 500 ft. in length. When the section is completely welded and the ditch in the river bottom dynamited, dredged or dug by jetting (in the case of quicksand) to a maximum depth of 8 ft. below bottom at mean low water level, the section is attached by cables to tractors on the opposite bank and pulled (and pushed by another tractor on the first bank) onto pontoons from which the section is guided to the bottom by stakes.

To hold the empty pipe in place beneath the bottom of a river, special river clamps are used. These clamps or anchors are 4 to 10 ft. long, weigh 1000 to 3000 lb. each and are bolted to the pipe and buried beneath the river bottom. Between six and nine clamps are employed on average 200-ft. crossings; the actual number depends on river currents and other local conditions. Bell-hole welds tie the river section into the line at either side of the river.

Many hundred such river crossings have been made; some of them have been called upon to withstand tremendous stresses during wash-outs and floods. It is a tribute to the quality of steel in pipe and the welds therein

Syphon to Carry Water Across a Shallow Valley Was Made of Bent Plate, Butt Welded in Shop to Convenient Lengths and Assembled in Field. Strength of joints is sufficient so that the pipe acts as a beam, requiring supports no closer than at 50-ft. intervals

that failures in such floods have been extremely rare, and then only when the devastation has been widespread and complete.

As it is essential that pipe joints be pressure tight, have strength and ductility at least equal to the pipe metal, and also possess high resistance to corrosion and be made at highest possible speed, the shielded arc process of metallic-arc welding is generally employed. Welds made by this process with "Fleetweld" electrodes possess a tensile strength of 65,000 to 75,000 psi., ductility of 20 to 30% elongation in 2 in., density of 7.84 to 7.86 g. per cc., fatigue resistance of 28,000 to 32,000 psi., and corrosion resistance greater than common steel pipe itself.

Arc-Welded Water and Steam Lines

Water lines of arc-welded field construction have proven highly successful. As in oil and gas lines, the joints insure a permanently tight, leakproof line with strength greater than the pipe itself.

The type of joints in water lines depends upon the size and wall thickness of the pipe and the pressure of the line. In several lines of 36-in. to 56-in. pipe, the "stab" or bell and spigot type has been used. On lines of larger sizes the joint is welded both inside and out. On one line 80 to 90 inches in diameter, a plain butt joint was used with a butt strap over the outside. This results in a bell and spigot reinforcement without the great expense of forming an expanded end on pipe of such large diameter.

Pipe for water syphons and conduits is usually of such size that roll welding is impractical, so the joints are welded in a fixed position, as described previously for bell-hole welding of oil and gas lines. The procedure also varies from that of oil and gas lines in that each pipe length is generally welded directly into the line instead of several being joined into sections and then connected into the line.

In the recent construction of a low-head syphon built of 111-in. diameter pipe, shown in the photo on page 47, a butt joint without bevel was used in the shop fabrication. The edges of the properly bent plates were butted together, tack welded, and the inside of all seams welded manually. This manually deposited weld metal then served as backing for the outside weld, which was made automatically by the shielded carbon-arc process. To make the automatic weld, the pipe was mounted on driven rollers, set to rotate the pipe at a speed of 1.32 ft. per min.

As an example of the economy of using arc-welded steel pipe in water line construction, a new supply line was recently completed at savings between 25 and 30% over conventional concrete construction.

Use of arc welding in erection of industrial and municipal distribution systems increases steadily. Many hundreds of miles of such piping systems, fabricated in shop and field, have been erected in office buildings, hospitals, schools, industrial plants, power houses and

Size Is no Limitation to Pipe Welding. Men are pigmies beside this giant steel manifold which brings water into one of the pumping stations along the aqueduct between Boulder Dam and Los Angeles

ships. High pressure, high temperature steam lines operating at 720° F. and 600 lb. have been completely erected by the electric arc. Welding simplifies the work by eliminating the many mechanical fittings otherwise required. It also greatly simplifies piping design. These advantages, plus the fact that the new method provides permanently tight connections of high strength and rigidity, while reducing resistance to flow by eliminating projections inside the pipe and lowering the cost of insulation — these advantages of electric welding are rapidly extending the use of the process in this field.

View in Welding Shop Showing a Number of Units for Underground System Fabricated to Dimensioned Drawings by Arc Welding. Contrast the "streamlined" joints with the flanged connections on several of the nozzles

Many typical examples could be cited. One of the best is a miscellaneous set of manifold assemblies for an underground steam distribution system. The economies of arc-welded piping, shop fabricated to dimensioned drawings, are obvious. To reduce them to figures the following costs have been assembled. Under "Welded" the cost includes all labor, supplies and power for bevelling two pipe ends and welding a butt joint. Under "Coupled" the cost includes the coupling, the cutting and threading of two pipe ends and the assembling. Under "Flanged" the cost includes two 125-lb. standard compression flanges of cast iron, a gasket and set of bolts, and the labor of cutting and threading two pipe ends and assembling the joints.

Comparative Cost of Joints

Pipe Size	Welded	Coupled	Flanged
2 in.	$0.50	$0.80	
4 in.	1.00	1.25	$2.50
6 in.	1.40	2.30	3.75
8 in.	1.75		4.75
10 in.	2.35		7.25
12 in.	2.90		9.15

Accounting for the steadily increasing use of electric welding in the construction of oil, gas and water lines and erection of industrial piping systems, is the constant improvement, by manufacturers, of welding machines and equipment. The modern portable arc welder for pipe line and other use is as far ahead of its predecessors in performance and economy as it is in appearance.

These modern machines are equipped with entirely new systems of arc control by which both arc heat and arc penetration may be adjusted in a continuous sequence of fine increments. This advanced feature makes the arc welder simpler and easier to operate than ever. The operator can obtain exactly the right arc to insure the highest degree of uniformity of performance. Also available is the improved device known as "Lincontrol" which permits the operator to regulate current *at the work*, regardless of his distance from the machine. Current can be raised or lowered merely by tapping the electrode on the work. The modern welding machine is also supplied equipped with a special time-delay idling device which, by slowing down the engine approximately 30 sec. after the arc is broken, saves up to 35% of the fuel consumption of the gasoline engine. The time-delay feature also assures maximum welding speed by giving time enough (30 sec.) to put in a new electrode without affecting the welding current.

Due to the quality of the results obtained by electric welding and because of the simplicity and economy it affords in pipe line and piping construction, use of the process in these fields is bound to increase. This is assured not only by the inherent simplicity and economy of the process but also by the constant research and development on the part of arc welding manufacturers to improve their products and thus still further increase the advantages available.

Photo Courtesy New Jersey Zinc Co.

The golfer
(as every sportsman)
depends on modern metals

NEW COPPER ALLOYS, AGE HARDENED, HAVE HIGH CONDUCTIVITY

By T. S. Fuller
Research Laboratory
General Electric Co.
Schenectady, N. Y.

TWO ALLOYS of copper containing beryllium have recently been developed by R. H. Harrington of the Research Laboratory, General Electric Co., and have been described by him in the literature. Both alloys show unusually high thermal and electrical conductivities coupled with excellent physical properties. Both are of the precipitation hardening type in which the unusual properties are developed by a quenching and aging treatment, or a modification of the aging treatment coupled with cold work.

The first alloy is made to contain 97% copper, 2.6% cobalt and 0.4% beryllium, the cobalt and beryllium being present in the ratio of one atom of cobalt to one atom of beryllium. Samples of this alloy cut from a 1-in. round cast rod show a Brinell hardness in the cast condition of 80, but when quenched in water from 900° C. (1650° F.) and subsequently reheated for one hour at 500° C. (935° F.) show a Brinell hardness of 220. The electrical conductivity of the alloy in the as-cast condition is 26% that of copper. When quenched from 900° C. in water, it is 20% that of copper, and when subsequently reheated to 500° C. it is 45% that of copper.

A series of experiments carefully performed indicates that maximum physical properties coupled with maximum conductivity are obtained when the alloy is quenched from 900° C. (1650° F.) and reheated at 500° C. (935° F.). So treated, the following physical properties have been obtained:

	Cast and Heat Treated	Forged and Heat Treated
Tensile strength, psi.	90,000	100,000
Proportional limit, psi.	45,000	45,000
Elongation, %	10	20
Reduction of area, %	20	24
Brinell hardness	220	220

Once precipitation hardened, the alloy may be reheated to about 500° C. (935° F.) without affecting the room temperature properties. Cold rolling to four numbers hard between the quench and the draw results in a small increase in tensile strength to a value of about 110,000 psi. The hardness and toughness of this alloy in the heat treated state prevent any practical attempts to cold work the heat treated alloy. The alloy is easily worked hot, before heat treatment, or cold worked between quench and draw. Modulus of elasticity at room temperature is 17,000,000 psi. in tension and 7,190,000 in torsion. The latter figure drops slightly to 6,960,000 at 400° C. (750° F.) These torsional modulus of elasticity values indicate an unusual maintenance of spring properties at temperatures up to 400° C.

The effect of temperature on the tensile properties of cast bars, quenched and reheated, is as follows:

	At 20°C.	At 350°C.	At 475°C.
Tensile strength	90,000	68,000	56,000
Elongation	10%	4%	1%
Reduction of area	20%	4%	2%

The second copper alloy of the pair mentioned at the outset contains chromium instead

of cobalt. The type analysis is 99.5% copper, 0.4% chromium and 0.1% beryllium. Again the chromium and beryllium are present in the ratio of one atom of chromium to one atom of beryllium, since experiments indicate that nothing is to be gained by adding chromium in excess of this amount. Samples cut from 1-in. round cast rods showed a Brinell hardness in the cast condition of 66. After quenching in water from 925° C. (1700° F.) and aging for one hour at 500° C. (935° F.) the Brinell hardness became 80 and the electrical conductivity of specimens so treated was 73% that of copper.

The physical properties of heat treated cast rods of this alloy follow:

Tensile strength	30,000 to 35,000 psi.
Proportional limit	15,000 to 16,000 psi.
Elongation	10 to 15%
Hardness	80 Brinell
Electrical conductivity	72 to 75%

By quenching 1¼-in. diameter cast rods after having been heated one hour at 900° C. followed by cold working to 1-in. diameter and subsequently heating for one hour at 500° C. (935° F.), Brinell hardness was raised to 108. Physical properties of material so treated are:

Tensile strength	46,200 psi.
Proportional limit	27,000 psi.
Elongation in 2 in.	20%
Electrical conductivity	73%

The properties of a specimen prepared by first casting in a mold 1¼ in. in diameter, followed by both the solution and precipitation hardening treatments, and subsequently cold swaging to 1-in. diameter, showed a tensile strength of 49,400 psi., proportional limit of 35,200 psi., with 12% elongation in 2 in., hardness of 125 Brinell and an electrical conductivity 67% that of copper.

The industrial applications of these two alloys naturally depend upon the coexistence of high physical properties coupled with unusually high electrical and thermal conductivities. The cobalt alloy under the trade name Trodaloy No. 1, when made into soldering tips and used at temperatures below 500° C., shows three to ten times the life of ordinary soldering coppers. Trodaloy No. 1 is used for electrodes in the resistance welding of stainless steel, and also for springs and for current-carrying shafts and bushings. Because of its ability to retain its strength at moderately elevated temperatures, it is also employed as electrode holders used in arc welding. The chromium alloy, under the trade name Trodaloy No. 7, is used principally for electrodes for resistance welding of steel.

FLUXES FOR SOFT SOLDER

By J. W. Willstrop, A. J. Sidery and H. Sutton

Abstracted from *Journal*, Institute of Metals, Vol. 59 (Advance Copy)

EXPERIMENTS were conducted at the Royal Aircraft Establishment to evolve a flux which would be free from the corrosive effects of the common zinc chloride flux (with or without hydrochloric acid) and at the same time improve the ease of joining such metals as corrosion resisting steels, zinc and aluminum bronze.

A large number of chemical compounds were tried; of them dibasic ammonium phosphate was found to be the only one of practical value. In this case it was observed that the solder began to unite with the high chromium steel after the soldering-bit had been applied long enough to heat the ammonium phosphate above its temperature of decomposition. It was concluded that the necessary fluxing action was due to the principal product of decomposition — meta-phosphoric acid.

As meta-phosphoric acid is, at ordinary temperatures, a hygroscopic solid and therefore not convenient to use in practice, it was decided to try ortho-phosphoric acid, which, in its commercial form, is a somewhat syrupy liquid having a purity of about 89%. Joints were made successfully in several common analyses of stainless steels, using a 65:35 tin-lead and a 50:47.5:2.5 tin-lead antimony. Likewise, the ease of "tinning" and soldering common steels and non-ferrous alloys appeared to be equal or superior than when using zinc-chloride flux.

While salt spray and other tests showed that we were progressing in the right direction, phosphoric acid dissolves many metals, and for many purposes the danger of residues of the acid in soldered articles would likely be objectionable. It was considered that by combining phosphoric acid with a volatile base weaker than ammonia the resulting phosphate might be superior to ammonium phosphate as a flux for soft soldering operations yet not possessing the possible objections to phosphoric acid. Of a number of organic nitrogen compounds selected, the most satisfactory results were obtained with the phosphates of aniline and toluidine. From considerations of cost aniline is to be preferred.

The three possible phosphates of aniline

(Continued on page 76)

SPOT AND SEAM WELDING (RESISTANCE) OF ALUMINUM ALLOY SHEET

By D. I. Bohn
Aluminum Co. of America
Pittsburgh

An Aluminum Alloy Canoe, Fabricated Almost Entirely by Resistance Welding, Is Sturdy When Afloat and Easily Handled Asho

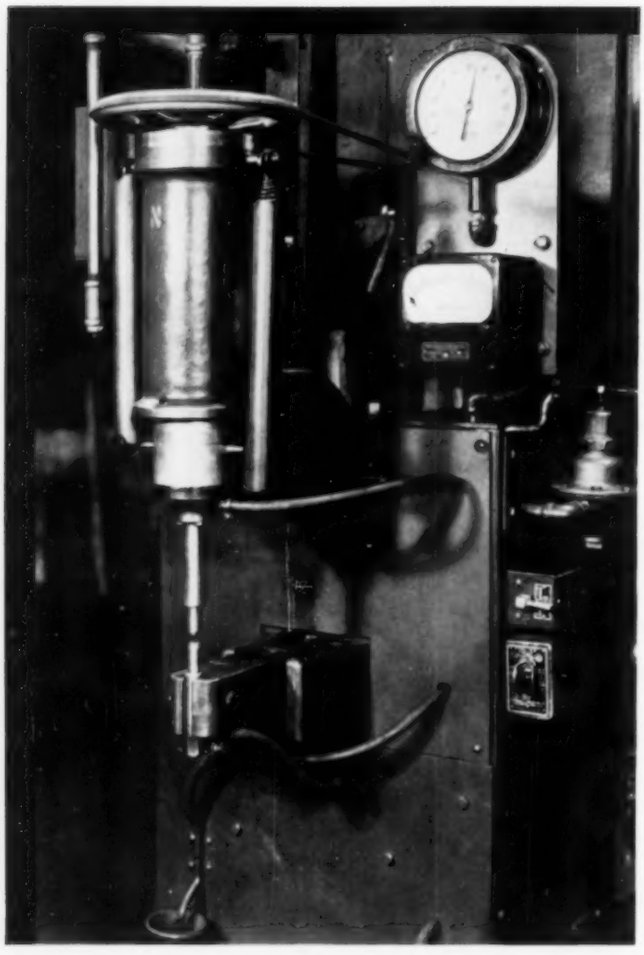
THE several types of resistance welding are today coming into quite general use in fabricating aluminum and aluminum alloy products. Lower costs, improved appearance, and a superior structural result combine to make these methods very attractive for many types of manufactured commodities. This growth of the various methods for resistance welding has been largely dependent on the development of suitable equipment since, in the large majority of cases, machinery that is employed for the resistance welding of steel is wholly or partially unsatisfactory for aluminum.

Intensive development work has therefore been carried on during the past few years by both the fabricators of aluminum alloys and the manufacturers of welding machinery. The necessary control equipment has likewise been brought to a high state of perfection by the electrical manufacturers. As a result, the aluminum alloys are normally welded by resistance on a production basis as quickly and easily as are other metals.

The various aluminum alloys can be resistance welded in any combination, although somewhat different machine adjustments are employed with the different analyses. These variations are normally insufficient to make much of any difference in the selection of suitable equipment.

The same general principles apply to spot and to seam welding. The spot welding process for aluminum involves:

1. Suitable electrode design and materials.
2. A rapid and practical means of applying pressure on the work at the electrodes.
3. A suitable surface condition of the materials being joined.
4. The passage of a suitable electrical current, of the proper value and time.
5. A machine design coordinating all these features so that the operation is automatic and relatively fast.



Welding Machines With Pneumatic Clamping Devices, Such as Illustrated Above, Require Automatic Timing of Pressure and Electrical Sequences

Hardness and high conductivity are the two attributes which make the most satisfactory electrode material. Suitable heat treated copper alloys are available which are considerably harder than hard drawn copper and have a conductivity of about 80% of standard copper. It is essential that these electrodes be kept cool by means of internal water cooling close to the welding surface.

Various electrode noses may be employed and either a conical contour or a rounded contour is satisfactory.

By making the electrodes quickly removable, it is not necessary to dress them up with a file, this being highly undesirable since a *uniform* contour cannot be maintained in this manner. Usually a number of machined electrodes are kept on hand for a day's production run, these being quickly refaced in the tool room in a small lathe.

Almost any mechanism to bring the electrodes together under pressure is satisfactory if properly designed. An air cylinder probably provides the most convenient method, as the reducer valve permits the pressure to be adjusted quickly and to be maintained accurately for successive spot welds. However, the mechanism involving the moving parts should be designed to reduce the hammer blow when pressure is applied. This is particularly true when some of the softer aluminum alloys are being welded, as a severe hammer blow will cause a large initial contact area, making satisfactory welds almost impossible.

Aluminum alloys are of considerably higher conductivity than the ferrous alloys. Consequently a machine for aluminum, to function properly, must be so designed electrically that a sufficient welding current is available.

Electrical Characteristics

The question is often raised in regard to the proper voltage at the secondary of the welding transformer, but this again is wholly a problem in machine design. Of itself, the secondary voltage has nothing whatsoever to do with the weld except that for a given design of machine a certain secondary voltage will be required to provide the necessary current.

To illustrate this more clearly, let us consider two machines, both of which will supply a maximum welding current of 25,000 amperes. One of these machines has a very short throat and small vertical distance between arms, providing a low impedance circuit for the secondary current. Such a machine might require an open-circuit secondary voltage of only 5 volts to force 25,000 amperes around its circuit. Another machine may be of relatively long throat and greater vertical distance between arms. The impedance of this machine will be much greater and may require an open-circuit secondary voltage of, let us say, 15 volts.

In so far as the welding capabilities go, these two machines are equivalent, as both of them will supply any desired welding current up to 25,000 amperes. The first machine however is far more economical to operate since it will require a maximum input of only about 125 kva., whereas the second machine will require three times this amount.

Similarly, a portable machine with several feet of secondary leads may require an even greater open-circuit voltage and a considerably greater power input (kva.) to do the same work.

Timing equipments, to switch the power on

and off, may be classified as synchronous and non-synchronous. Synchronous control, usually of the electronic type, may be adjusted so that the power is applied at such a point with respect to the voltage wave that unsymmetrical transients do not occur during the first few half-cycles as compared with those which subsequently take place. The use of such a control is desirable where welds of the highest quality are necessary, and equipment of this type is largely employed with the heat treated alloys to obtain the best structural result.

is passed between the electrodes. These schemes are many in number and are a safeguard against improper operation.

Most of the heat treated alloys of aluminum and some of those requiring no heat treatment require that the surfaces contacting the electrodes be cleaned, either abrasively or mechanically, in order to insure no undue local heating on the outer surfaces of the material. In some cases, both internal and external surfaces are so cleaned.

For successful welding the current must be

Spot Welding of Aluminum Cooking Utensils (in This Case a Tea Kettle) in Production

Non-synchronous control, usually involving a small electronic or mechanical timer operating a contactor, is in quite widespread use for fabrication not requiring the most consistent results, so the use of such equipment is largely employed with those alloys of aluminum that do not require precise heat treatments to develop their valuable properties.

With certain types of machines, particularly those obtaining their pressure from a pneumatic cylinder, some device for controlling the sequence of operations is necessary so that the operator's judgment is not required to insure that the pressure is fully applied before current

easily adjustable. This may be done either by tapped switches on the welding transformer or by means of a separate auto-transformer. The latter is preferable for machines of relatively large electrical rating, as a non-tapped transformer will have a substantially lower reactance than one with tapped switches when it operates at the high current values. Power absorbed in the transformer represents an extra and undesirable demand on the supply system.

An appended table gives approximate values which may be used in specifying the currents and pressures which a machine must be designed for in order to do a certain maximum gage of

work. Various alloys, tempers, and surface conditions may require some variation from the figures in this table.

Seam Welding

A seam welder is merely an automatic and continuous spot welder employing rollers for electrodes and demanding a synchronously interrupted current supply. General considerations with respect to machine design and other features discussed above for spot welders apply to seam welders. Because a seam weld is essentially a series of overlapping spots, currents are generally about 25% higher than with spot welding, for a considerable proportion of the current is diverted through the weld previously made.

Since the electrode rollers do not separate from the work during the making of a seam weld, synchronously interrupted power is absolutely essential. If non-synchronously interrupted power is employed a resultant unbalance between plus and minus half-cycles will cause a saturation of the welding transformer, and prevent its further operation.

Various "on" and "off" combinations are employed for different gages of material. These are usually selected so that the "on" period is not over one-third of the "off" period, and preferably less. A combination of a suitable cycle adjustment and feet per minute gives the desired number of overlapping spots per inch.

By establishing a fairly long "off" period and increasing the speed of the work, a seam welder may be used to make an intermittent seam weld, and give the same result as a succession of ordinary spot welds. Where this method is physically applicable, the speed of production is many times that of spot welding.

Tentative Machine Settings For Spot Welding Aluminum Alloys

Gage		Time in Cycles	Current in Amperes	Tip Pressure in Lb.	
B. & S. No.	Inches			Minimum	Maximum
26	0.016	4	14,000	200	400
24	0.020	6	16,000	300	500
22	0.025	6	17,000	300	500
20	0.032	8	18,000	400	600
18	0.040	8	20,000	400	600
16	0.051	10	22,000	500	700
14	0.064	10	24,000	500	700
12	0.081	12	28,000	600	800
10	0.102	12	32,000	800	1000
8	0.128	15	35,000	800	1200

TANTALUM IRONS & STEELS

By R. Genders and R. Harrison

Summary of paper for British Iron & Steel Institute, Sept. 1936 meeting

TANTALUM-IRON alloys may be considered (structurally) as a system of iron and the compound Fe_2Ta, whose solubility in alpha iron is small at low temperatures. Its solubility in gamma iron increases with temperature to about 3% tantalum at the eutectoid (1220° C. or 2230° F.).

Hardness is increased progressively to about Vickers 170 (annealed) or 200 (quenched) at 7% tantalum. The quenched supersaturated solid solution is stable up to about 1100° F. Above that temperature a moderate amount of hardening occurs in the low tantalum alloys after tempering 1 to 5 hr. Experiments on the cementation of Armco iron with ferrotantalum gave negative results.

The constitution of carbon steels containing tantalum and niobium, and made from commercial materials, may be broadly connected with that of the pure tantalum-iron alloys. With increasing tantalum content, the proportion of carbon in the form of iron carbide is progressively reduced, and above a certain concentration of tantalum, depending on the carbon content, the steels become essentially tantalum-iron alloys containing inclusions of an additional hard carbide constituent which appears insoluble. For example, in a 0.40% carbon steel the effect of only 1% of tantalum is to reduce considerably the proportion of pearlite in the steel, the structure consisting mainly of ferrite grains containing distributed fine particles of another constituent. Very little pearlite was observed in the 3% tantalum steel, and with 6.6% or more of tantalum the structures were similar to those of the carbonless alloys. Quenching from 2100° F. produced areas of martensite in the 1% tantalum steel, but none in those containing higher percentages.

Certain of the tantalum steels containing above 10% of tantalum show a relatively small reduction in strength on testing at 950° F., but in view of the difficulty of working these materials it is doubtful whether they have any promising application. At temperatures above 1850° F., oxidation is extremely rapid, producing a thick, adherent scale.

(Continued on page 92)

Crystallography of the Chemical Elements

As Tabulated by William Hume-Rothery
in "The Structure of Metals and Alloys" Monograph No. 1, British Institute of Metals

Element Atomic No.	Electron Arrangement in Free Atoms	Crystal Structure (note a)	Axial Ratio c ÷ a	Coordination No.	Lattice Constant a	Lattice Constant c	Interatomic Distance d_1	Interatomic Distance d_2	Atomic Diameter (Coordination No. 12)
Group IVA in Periodic Sequence									
22 Titanium	[2][8][10]2	⬡	1.601	6,6	2.953	4.729	2.915	2.953	2.93
40 Zirconium	[2][8][18][10]2	α=⬡	1.589	6,6	3.223	5.123	3.166	3.223	3.19
(data for 867°C.)		β=⧈	—	8	3.61	—	3.126	—	—
72 Hafnium	[2][8][18][32][10][2]	⬡	1.587	6,6	3.200	5.077	3.139	3.200	3.17
90 Thorium	[2][8][18][32][18][10][2]	⊡	—	12	5.077 or 5.091	—	3.590 or 3.600	—	—
Group IVB, Including Carbon and Silicon									
6 Carbon, diamond	[2]4	◇	—	4	3.5606	—	1.5113	—	—
graphite	—	⬡ (b)	2.75	6	2.46	6.78	1.42	2.46	—
14 Silicon	[2][8]4	◇	—	4	5.418	—	2.346	—	—
32 Germanium	[2][8][18]4	◇	—	4	5.647	—	2.445	—	2.788
50 Tin, gray	[2][8][18][18]4	◇	—	4	6.46	—	2.797	—	3.164
white	—	△	0.5456	4,2	5.8194	3.1753	3.0161	3.1753	—
82 Lead	[2][8][18][32][18]4	⊡	—	12	4.9389	—	3.4923	—	3.494
Group VA in Periodic Sequence									
23 Vanadium	[2][8][11]2	⧈	—	8	3.033	—	2.627	—	2.69
41 Columbium	[2][8][18][12]1	⧈	—	8	3.294 ±0.001	—	2.853	—	2.94
73 Tantalum	[2][8][18][32][11]2	⧈	—	8	3.298 ±0.002	—	2.854	—	2.94
91 Protoactinium	[2][8][18][32][18][11]2		—	—	—	—	—	—	—
Group VB									
7 Nitrogen	[2]5	α=cubic	—	—	5.66	—	1.06	—	—
15 Phosphorus	[2][8]5	□	α=34° 7′	3,3	5.14	—	1.74	3.01	—
33 Arsenic	[2][8][18]5	□	α=53°49′	3,3	4.151	—	2.5086	3.1465	—
51 Antimony	[2][8][18][18]5	□	α=57° 5′	3,3	4.497	—	2.879	3.378	3.228
83 Bismuth	[2][8][18][32][18]5	□	α=57°16′	3,3	4.7365	—	3.105	3.474	3.64
Group VIA in Periodic Sequence									
24 Chromium	[2][8][13]1	α=⧈	—	8	2.8786	—	2.4929	—	2.57
		β=⬡	1.626	6,6	2.717	4.418	2.709	2.717	2.71
42 Molybdenum	[2][8][18][13]1	⧈	—	8	3.1403	—	2.7196	—	2.80
74 Tungsten	[2][8][18][32][12]2	α=⧈	—	8	3.1583	—	2.7352	—	2.82
		β, (c)	8 atoms in unit cell →		5.038		2.519	2.816	
92 Uranium	[2][8][18][32][18][12]2	Mono-clinic	a:b:c=1:1.73:1.17 β=64°18′		2.829	3.308 b=4.887	2.829 ← Note d		—
Group VIB									
8 Oxygen	[2]6	—	—	—	—	—	—	—	—
16 Sulphur	[2][8]6	□ (d)	2.315	—	10.61	24.56	—	—	—
34 Selenium	[2][8][18]6	⬡ (e)	1.140	2,4	4.337	4.945	2.316	3.457	—
52 Tellurium	[2][8][18][18]6	⬡ (e)	1.33	2,4	4.445	5.912	2.858	3.46	—
84 Polonium	[2][8][18][32][18]6	—	—	—	—	—	—	—	—

Notes: (a) ⧈ is body-centered cubic; ⊡ is face-centered cubic; ⬡ is close packed hexagonal except as noted; ◇ is diamond; △ is tetragonal; □ is rhombohedral and ▯ is orthorhombic

(b) Graphite is hexagonal, not close packed, with four atoms per unit cell.

(c) Cubic structure; two positions distinguishable, X and Y. Each atom X has 12 Y at 2.816 Å; each atom Y has 2Y at 2.519 and 4X at 2.816 Å

(d) 128 atoms in unit cell. Data from International Critical Tables or A.S.M. Metals Handbook

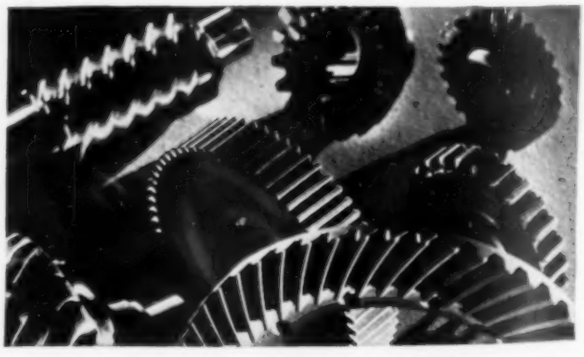
(e) Hexagonal, not close packed; each atom has 2 neighbors at d_1 and 4 at d_2

IT TAKES PLENTY OF SHOCK RESISTANCE TO SURVIVE A 20 TON KICK!

THE steel foundry, as well as the iron foundry, adds Nickel to many a composition. Adds it to fortify steel castings against the ravages of impacts, fatigue, stresses, and wear. That Nickel helps these castings live to a riper service age is proved by some of the case histories cited here. The two Pullmans shown are about to be joined with coupler knuckles (see inset) of Nickel Cast Steel. Just remember that when the impact comes there's a 20-ton bump between metals—and that there are heavy tensile and compressive stresses when the train starts and stops. Since 1928 most of these Pullman coupler knuckles have been made of Cast Nickel-chromium Steel. More than 10,000 have been placed in service. The possibilities of effecting long run economy in your equipment make the Cast Nickel Steels well-worth investigating.

NO service records are available for this particular collection of Nickel Cast Steel gears. But we have plenty of case histories of others of the same type and compositions that prove the ultimate economy of this material. An interesting photograph, this, from a number of standpoints, but especially interesting to makers and users of machinery because it shows how broad a range of gear applications may be supplied by strong, tough Nickel Steel castings. We invite consultation on the use of cast and wrought Nickel Steels, Nickel Cast Irons and other alloys containing Nickel in your equipment.

THESE curious globular castings came from the locks of the Panama Canal. They are called pintles—pivots on which the huge 79-ton lock gates turn. Before they were removed 20 years of service were chalked up to their credit. The one on the left (pressure side) shows only slight evidence of wear: the one on the right (slack side) shows dirt and scale but no wear. Another example of the downright economy of the Nickel Cast Steels.



NICKEL CAST STEELS

THE INTERNATIONAL NICKEL COMPANY, INC., NEW YORK, N.Y.

INTERRUPTED SPOT WELDING USES ELECTRON TUBE CONTROL

By R. S. Pelton
Works Laboratory
General Electric Co.
Schenectady, N. Y.

RESISTANCE WELDING, as is well known, requires the passage of heavy electrical currents through the adjoining pieces of metal to be united. Resistance offered to the passage of this current heats the metal at and beneath the contact surfaces and when the temperature is sufficiently high a mechanical squeeze will cause localized union. The equipment required is therefore some form of press whereby the parts are held and forced together, a source of current of proper voltage and amperage and a system whereby these forces and currents can be controlled in time and amount.

Practical embodiments of these principles take the most diverse forms; very frequently machinery is designed and built especially to handle one particular part in production. Much thought has also been given to automatic control devices whereby the proper sequence of mechanical pressure and electrical current, as well as the amount and duration of each, is assured. Eliminating the personal equation of the machine tender is desirable in almost all cases; in many high speed operations it is absolutely essential.

Originally such control devices depended largely on linkages, cams, gearing and other mechanical elements. An early development was the installation of driving motors synchronized with the welding circuits. Rapid work, as on a machine making a seam of a series of overlapping spot welds, required that such control machinery be of the utmost precision and carefully maintained. In many instances (such as the joining of one metal to an unlike one, joining heat treated or special alloys, joining of extremely thin metals or parts of large difference in mass) good welds required control accurate to a small fraction of a power cycle — beyond the capabilities of mechanisms.

Hence the utilization of electron tubes for the closer control of the electrical current followed quickly upon their commercial production. That type of tube known as the "thyratron" (a vapor-filled tube with a control grid) was early used to replace troublesome and noisy contactors on high capacity welders. Shortly thereafter, thyratron synchronous timers were substituted for the cam operated control switch. More rugged tubes of new design and simplified circuits now permit the control of a 300-kva. spot welder (for instance) with six tubes wherein the time of current dwell may be adjusted simply by turning a dial, from one to 30 cycles in one-cycle steps.

Thyratron control is by no means a complete cure for all the ills of resistance welding, but it has at least eliminated three of the most serious problems with which users of resistance welding have been faced: First is the inaccuracies of control devices with reference to the time of power application or dwell. Secondly, similar inaccuracies of such equipment are avoided where the *instant* of starting current flow with

respect to the voltage wave is involved. Finally, electron tubes cut the high maintenance cost of mechanical control on seam welders and high-speed spot welders. Another major reason why equipment manufacturers are swinging to thyratron control for their spot and seam welders lies in the fact that the speed of welding can often be multiplied several times with no sacrifice in quality — in some cases, it has resulted in a decided improvement in quality. Finally, through the use of this method of control using electron tubes, a new welding process, known as "interrupted spot welding," has been developed.

It will now be my endeavor to outline this process of interrupted spot welding, rather than enter into a discussion of the electrical theory underlying the control devices — a matter somewhat aside from the interests of users of equipment for metal fabrication. Likewise, it is unnecessary to do so, for it has been excellently covered in a series of articles in *General Electric Review*, February to June, 1937, inclusive.

This process of interrupted spot welding has extended the application of both spot and projection welding in three ways: It has made it practical to spot weld pieces together several times as thick as was practical before. Regardless of this point, the application of this principle also increases the capacity of any given spot welding machine with regard to the thickness of the parts which may be welded by that particular machine. Interrupted spot welding has also been a great aid with those jobs that produce "splash" or tend to blow out weld metal.

Multiple Shots of Current

Briefly, the process consists in the application of repeated impulses of power or current, instead of a single application of power, when making a single spot weld or a single projection weld. These multiple electrical impulses occur during a single application of pressure, or a single operation of the welding machine. Such a condition of affairs may obviously be accomplished by the use of a seam welder interrupter in connection with a regular spot welder control. More satisfactory results, however, are obtained with a thyratron control especially designed which applies a certain predetermined number of impulses of power, each "on period" synchronously timed with an "off period," the sequences being adjustable over a wide range of times.

The first benefit derived from the application of interrupted current in spot welding was an increased electrode life. For example, a previous difficulty when trying to spot weld thick pieces of steel together was that when sufficient heat and pressure were applied, the electrode materials would anneal and "mush out," and frequently fuse to the steel held between them. This condition was also associated with relatively intense heating of the parts being welded out to and including their external surfaces. That this can be corrected by interrupting the welding current momentarily a number of times is illustrated by the extreme case of two lapped pieces of 1x3 in. carbon steel plate. The half tone opposite shows the grain structure at the spot weld. Each weld was made in one minute, wherein the total application of power was 30 sec. — that is, there were 30 applications of power, each 60 cycles long, with 60 cycles off between impulses. (Incidentally this sample broke at 118,000 lb. load in tension.)

Water-cooled electrodes are necessary to obtain maximum benefit. The time off between impulses of power allows the water to control the temperature of the electrodes, yet the delay is not sufficient to lose appreciable heat from the mass of metal to be welded. It can be seen that the grain structure in the surface in contact with the electrodes is practically unchanged. An unchanged outer surface is frequently desirable to resist external corrosion, but the principal point now stressed is that this procedure increases the electrode life many times.

In some cases, it is desirable to accompany the spot welding operation with an annealing treatment. A spot weld made too quickly in a hardenable steel results in a severely quenched condition, especially if the electrodes dwell on the spot appreciably after the weld is made. Likewise formed parts in low carbon steel presenting severely cold worked material for spot or projection welding will frequently recrystallize into a coarse grained, brittle weld. Either of these cases is benefited by "soaking" it with additional heat after the weld is made, and may be treated in one of two ways: After the weld is completed less heat is generated by the current, so that if a low value of interrupted current is used the final impulses may supply heat only as fast as it radiates through the material. If greater speed is desired, any one of several automatic devices may be used to cut the value of the applied current for the final impulses, first having made the weld quickly. Heat treat-

ment may be applied in this way with very little grief to the electrodes.

It seldom occurs that the first impulse of power will make a satisfactory weld. Ordinarily, each impulse of power serves to raise the temperature in the weld zone until a weld of sufficient size is made. This gives a water-cooled welding transformer the same advantage as the water-cooled electrodes have in welding the heavier pieces. Various combinations are used ranging from one cycle on and one cycle off, which is a help on some projection welding jobs, to 60 cycles on and 60 cycles off for spot welding some heavy sections as illustrated on this page. The general rule is not to have the time off exceed the time on; sometimes the combination is only one or two cycles off with six or eight cycles on. Some production jobs are using only three or four impulses of current while some jobs require 25 to 30 impulses.

With the many different metals and alloys and all the combinations of thicknesses, shapes of parts, and designs of projections, it is still largely a matter of cut-and-try to determine what combination works best on a particular job. The heat tap, or current setting, is related intimately to the timing, yet the *number* of impulses is not so critical. Thus, if a normal spot weld is being made with six impulses, an additional one will do no harm and one less will leave the weld only a little smaller, other factors remaining the same.

Contact resistance is a very important factor, controlled by both the pressure and the surface condition of the parts to be welded. The surface conditions may influence not only the current setting, but also the timing required to avoid splash, or to get a real weld instead of only pasting the parts together.

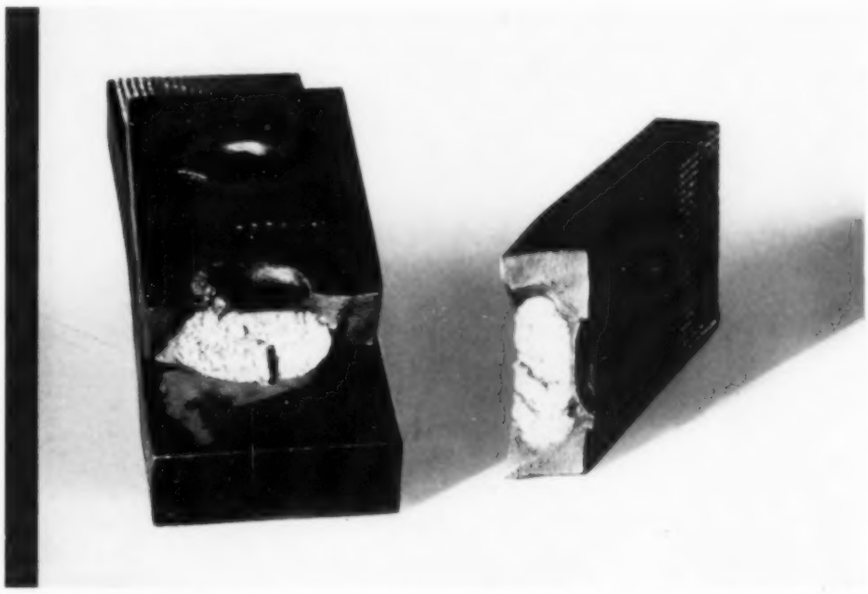
It is recommended that formed parts always be made to fit properly before putting them into the welding machine. However, when the welding machine must be used for a forming press, it is a help to allow enough time so that heat can soak out into the metal which is to be bent or deformed. Periodically interrupting the current flow in such a case allows the electrode forms to be maintained while the metal is heated more slowly and extensively, pushed down, and finally welded.

General Recommendations

It is hoped that the following remarks will serve as somewhat of a guide in choosing a correct combination of "on periods" and "off periods."

With heavy sections — that is, when both parts are thick — the "off period" should more nearly equal the "on period." This will give the water cooling a better opportunity to keep the electrodes in condition to withstand the higher pressure necessary, yet, with these thicker sections, each impulse of power will add additional heat to the joint between the pieces.

Long times (as 30 impulses, each 60 cycles on and 60 cycles off) may require a greater time of pressure dwell than the machine will give without stopping the motor, when a motor operated welder is used. When such jobs are not too frequent, they may be accomodated conveniently by stopping the motor with the pressure on, and then starting the motor again



Momentarily Interrupting the Welding Current Many Times During the Making of a Spot Weld Permits the Electrode to Be Adequately Cooled and so Lengthens Its Life. Note that the outer surface of the steel at the spot has not been heated above the recrystallization temperature

after the weld is completed. An alternative is to install a sequence control and a motor with a brake to stop it at the desired position.

With medium heavy jobs, where the total thickness of both parts is one inch or less, around 30 cycles of current on with 20 cycles off is commonly used. The number of impulses is frequently five or six, although with some more critical jobs a lower current value with 10 to 15 impulses is used.

When thinner sections are being spot welded shorter impulses are used, and the proportionate time off must be reduced or the chilling action of the electrode will affect the temperature at the inner surfaces or weld joint.

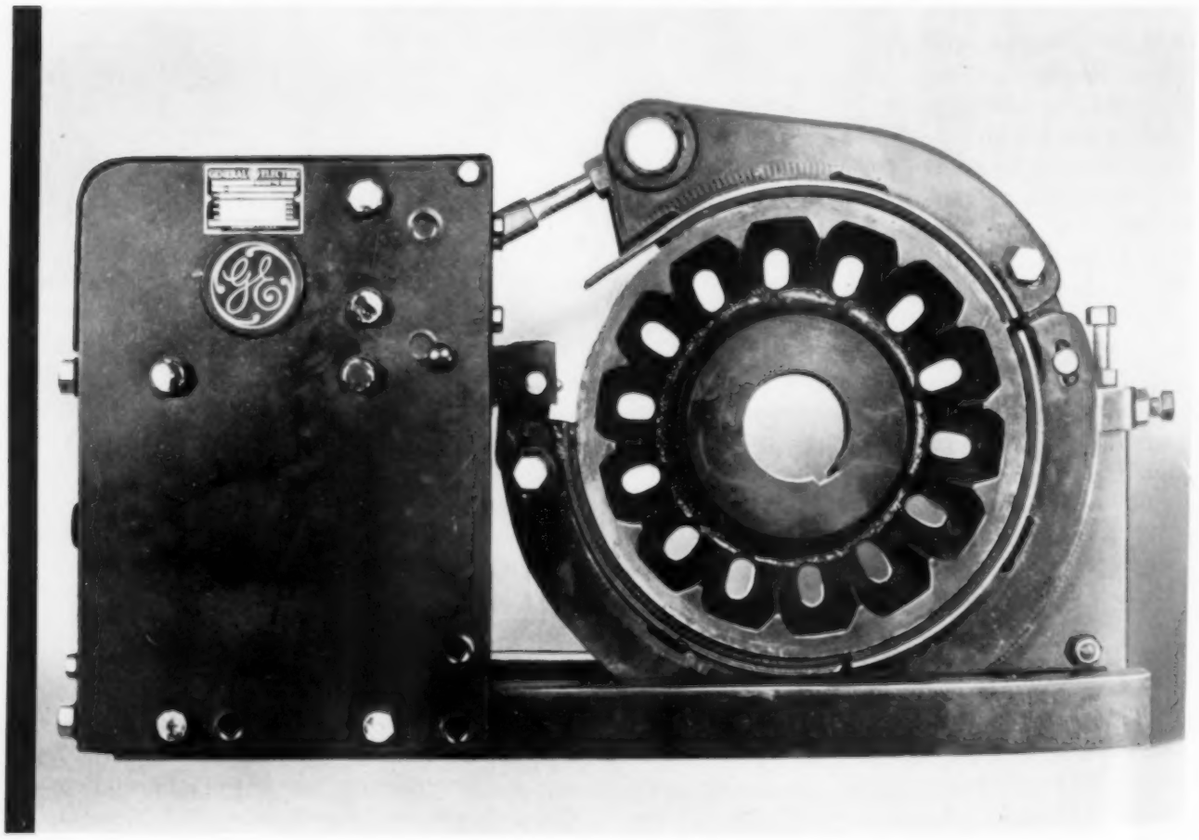
When a spot weld must be made too near the edge of a piece, or when a narrow strip is to be spot welded to another piece, the tendency of the material to splash or mush out is greatly reduced by using an interrupted current. (By "narrow strip" is meant a strip perhaps no wider than the electrode contact surface.) In either of these cases, the time off should nearly equal the time on so that the material next to the electrode will be kept cool enough to resist "mushing" while the heat is built up more slowly and confined closely to the joint. For a narrow strip of aluminum $\frac{1}{16}$ in. thick, six impulses were used with three cycles of alternating current on and three cycles off.

Projection welds take a large variety of forms. One common type involves the setting of studs or bosses onto plate stock. To weld $\frac{5}{8}$-in. diameter steel studs onto $\frac{3}{16}$-in. plate, eight impulses with two cycles on and two cycles off produce a tougher and better weld with less splash than was ever obtained before by any other procedure of resistance welding known to the writer.

For $\frac{7}{8}$-in. round studs onto $\frac{1}{4}$-in. plate, 13 impulses with four cycles on and four cycles off proved very satisfactory. The dome on the end of these studs was spherical with about a 2-in. radius.

To mount a long bracket of $\frac{3}{16}$-in. steel onto a curved surface of $\frac{1}{8}$-in. stock, eight projections $0.030 \times \frac{3}{16} \times \frac{7}{16}$ in. were used. Three impulses of nine cycles on with seven cycles off give a better and more uniform result than was ever obtained by a single shot of current.

Five Spot Welds Made by the Interrupted Method Attach Securely Internal Fittings to Each Side Plate in the Housing for This Magnetic Brake



CORRESPONDENCE AND FOREIGN LETTERS

Erroneous Interpretations of Studies Under Polarized Light

Special Letter to METAL PROGRESS

by Albert M. Portevin
Professor, Ecole Centrale des Arts et Manufactures

PARIS, FRANCE—Although examination under polarized light has been used frequently in mechanics to determine the internal stresses in transparent models (photo-elastic studies) and in mineralogy for the determination of constituents of rocks (petrographic studies), it has not found much application in metallography, although it was recommended by Koenigsberger as early as 1909. This method may prove very useful in the same two applications mentioned above. Metallographic phenomena, however, are more complex and may present sources of error in interpretation that must be guarded against.

In the first place, the phenomena are somewhat obscured because of the fact that examination is by reflection and because modifications in the surface caused by polishing and etching are inevitable.

Bi-refringent crystals are not generally totally extinguished; isotropic crystals likewise are not always absolutely black between crossed nicols. This originates from the fact that in the polarizing metallurgical microscope the numerous parasitical reflections and refractions due to the vertical illuminator and ocular prism modify slightly the polarized cone reaching the analysis apparatus.

It is generally found that metallographic examination under polarized light is hampered by the feeble intensity of the reflected light, thus requiring too long an exposure for photography. Anisotropic crystals can be revealed without etching; indeed the roughening caused by preliminary etching may even be detrimental to clearness, since it diffracts the light. Furthermore, considerable attention must be paid to the quality of polishing in order to avoid surface deformation which would conceal the orientation of the underlying crystals.

Errors of interpretation may moreover be made because of parasitical reflection phenomena which appear to be caused by a bi-refringence that does not actually exist.

Thus, in *Archiv für das Eisenhüttenwesen* for October 1936, page 155, P. Schafmeister and G. Moll were led to attribute the existence of "stresses" in amorphous, globular silicate inclusions in steel, because they showed between crossed nicols a black cross with bright colored concentric rings, the cross remaining stationary when the microscope stage was moved. This phenomenon did not disappear when the sample was annealed.

It should be remembered in this connection that R. W. Dayton (A.I.M.E. Technical Publication No. 593, January 1935) proved geometrically that this phenomenon of the black cross occurs without any anisotropy for any transparent isotropic inclusion having a spherical base; an elliptical polarization occurs by reflection, from the base of the inclusion, of minimum effect in

the directions parallel to the polarization planes and of maximum effect in a direction at 45° to these planes. The black cross is the result of this phenomenon and it is not necessary to explain its existence by assuming the presence of somewhat hypothetical stresses. Moreover, it is symptomatic that in metal containing such spherical inclusions, the black cross remains even after heat treatment at high temperature, when the "stresses" should have disappeared.

Likewise, transparent inclusions which have been elongated by rolling, such as the vitreous manganese silicates, present entirely analogous elliptical polarization phenomena by reflection from the base. This effect also is at a maximum when the axis of elongation of the inclusion is at 45° to the direction of polarization. As this position is obtained four times in each revolution of the stage, it is not surprising that four successive positions of extinction and illumination may be observed, thus leading to the belief that the elongated inclusion is crystallized and anisotropic (and even that it is formed by a single crystal with its axis in the direction of elongation).

The following very simple experiment will illustrate the accuracy of this reasoning:

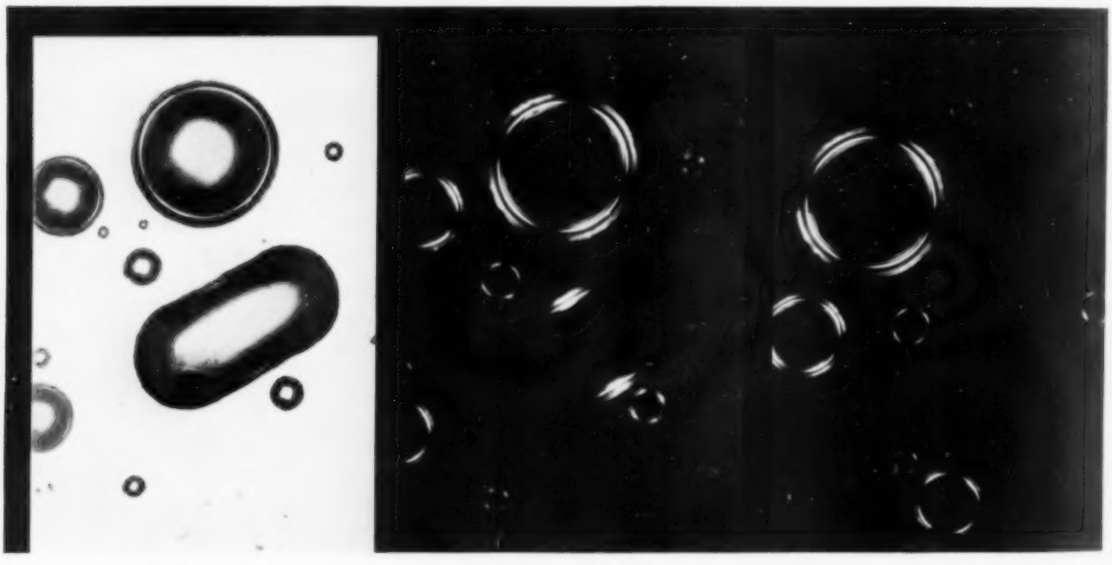
If droplets of glycerin are atomized on a slightly greased, polished metal surface, they will not wet the surface and will therefore take either a hemispherical or a more or less oval, elongated shape. These droplets, when examined under polarized light between crossed nicols, will show the phenomenon of the black cross when they are round in shape, and when elongated will show four successive extinctions and illuminations for each revolution of the microscope stage.

This phenomenon is photographed and reproduced herewith. While not exactly identical, since there is inversion in the relief in relation to the surface of the sample, it is still closely akin to that presented by globular or elongated inclusions of vitreous and transparent silicates in steel. It can hardly be assumed that glycerin acquires the optical properties of a bi-refringent crystal under the simple influence of its surface tension. Observations of inclusions under the polarizing microscope should therefore not be interpreted hastily, especially when dealing with transparent or highly translucent inclusions.

Finally, the advantages of conic light in the determination of inclusions should be noted, especially in discerning opaque and transparent inclusions without the use of polarized light. This has been discussed by the writer and René Castro at the British Iron & Steel Institute meetings in September 1935 and 1936.

ALBERT PORTEVIN

Professor Portevin Refutes Idea That "Black Cross" in Transparent Inclusions in Metals Indicates Internal Stress by Showing Same Phenomenon in Glycerin Droplets on Slightly Greased Metal Surface (150 Diameters)



Parallel nicols | Crossed nicols | Same as middle but stage rotated 45°

Wear Testing

Comments on Articles in METAL PROGRESS
by Samuel J. Rosenberg
Asso. Metallurgist, Bureau of Standards

WASHINGTON, D. C. — Although the problem of wear testing has many ramifications, and differences of opinion among investigators are not uncommon, certain principles are agreed upon. One is that there is not, and can never be, a "universal" wear test. This is a logical corollary of the fact that there are many different types of wear and that a material which is most advantageous in a certain application may be useless in a different one. A consideration of these facts leads to the conclusions that wear testing equipment must be designed to simulate actual service conditions, that results from any type of wear test cannot be accepted until it has been proved that those results actually check service data, and that the rating of materials obtained by any one test cannot be applied to any different type of wear. These conclusions have frequently been confirmed by careful experimenters, and the literature is quite consistent.

There appeared, in the March 1937 issue of METAL PROGRESS, a very interesting article, "The Relative Wear of Some Hard Metals," by Robert B. Freeman. In the April issue Dr. Freeman, in collaboration with Donald S. Clark, described "A New Test for Relative Sliding Wear." The purpose of this test was to accelerate the determination of the resistance of materials to sliding wear and a few data are given to show that this test is suitable for that purpose.

The apparatus described in the March issue is designed to simulate sliding metal-to-metal wear, and when pressure, speed, and other factors are properly controlled, the authors may reasonably expect to secure data which will be applicable to service conditions involving sliding wear. The use which is immediately suggested by the description of the test is the determination of the wear resistance of materials used for brake shoes on car wheels. The accelerated test method for determining resistance to sliding wear, described in the April issue, does not involve the same type of wear which exists in the test described in the March issue. This accelerated test method is really a measure of the resistance to scratching or cutting, or a combination of both, and it is quite probable that if many materials are tested, the two testing methods will not rate them all in the same order.

A study of the data given in the March article reveals that the wear of any material in this type of test is dependent upon the material with which it is in contact, the pressure between the two and rate of slip (to mention only three factors). Since so many factors enter into the determination of the wear resistance of a metal in this machine, and some of these are altogether different and others are not even present in the cutting or scratch test method described in the April issue, it should not be expected that the latter test will give results similar to those obtained with the first.

The complexity of the problem of wear really can be appreciated only by those who have worked in this field. When one considers the amount of time and effort which has been spent in wear testing, the sum total of our knowledge on this subject is surprisingly small. One or more of the technical societies can render a real service to the metal industries by sponsoring an extended study of wear and wear testing. A program of work should include a tabulation of the various types of wear, a study of the mechanism of each type of wear and the effect of pertinent influencing factors, a critical study of all available wear testing methods and a determination of the type of wear most closely simulated by each method, and the proper interpretation of test data. All test data secured in such a study should be extensively checked against service results. Such a program, carefully planned and painstakingly executed, might lead to a sufficient understanding of wear to enable the ultimate standardization of certain types of wear tests and a clear understanding of the applicability of the test data obtained therefrom.

SAMUEL J. ROSENBERG

Reply by Messrs. Clark and Freeman

PASADENA, CALIF. — The results of wear tests carried on at the California Institute of Technology and reported by Robert B. Freeman in the March 1937 issue of METAL PROGRESS, were in answer to a direct problem concerning sliding wear. In observing the results of those tests, it was believed that for certain materials wear took place by the removal of metal by cutting or scratching. An investigation of this fact was therefore undertaken, and it is reported in the April 1937 issue.

The results of this study do not warrant the

the directions parallel to the polarization planes and of maximum effect in a direction at 45° to these planes. The black cross is the result of this phenomenon and it is not necessary to explain its existence by assuming the presence of somewhat hypothetical stresses. Moreover, it is symptomatic that in metal containing such spherical inclusions, the black cross remains even after heat treatment at high temperature, when the "stresses" should have disappeared.

Likewise, transparent inclusions which have been elongated by rolling, such as the vitreous manganese silicates, present entirely analogous elliptical polarization phenomena by reflection from the base. This effect also is at a maximum when the axis of elongation of the inclusion is at 45° to the direction of polarization. As this position is obtained four times in each revolution of the stage, it is not surprising that four successive positions of extinction and illumination may be observed, thus leading to the belief that the elongated inclusion is crystallized and anisotropic (and even that it is formed by a single crystal with its axis in the direction of elongation).

The following very simple experiment will illustrate the accuracy of this reasoning:

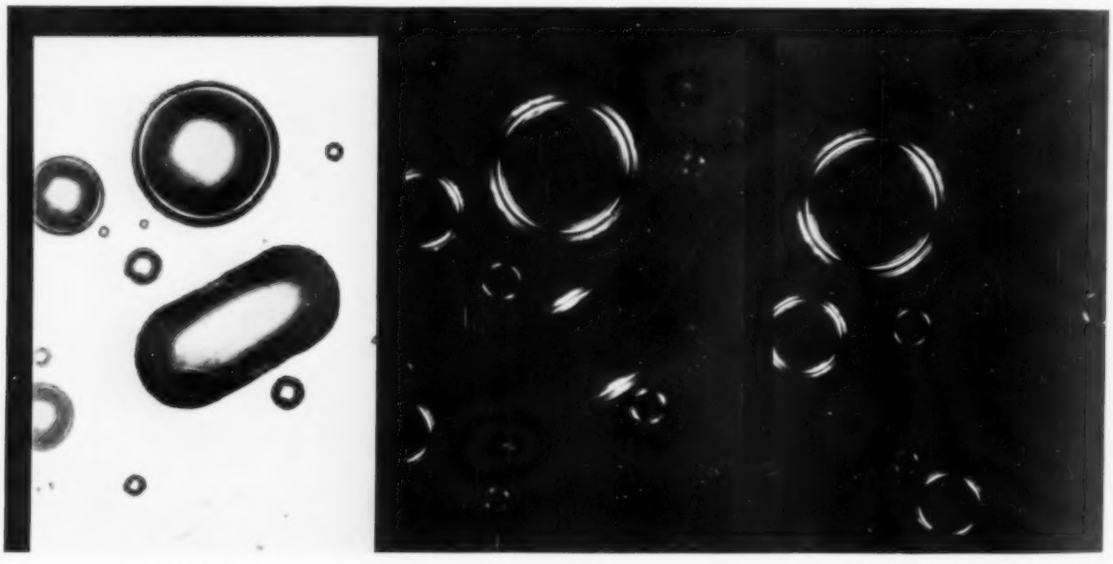
If droplets of glycerin are atomized on a slightly greased, polished metal surface, they will not wet the surface and will therefore take either a hemispherical or a more or less oval, elongated shape. These droplets, when examined under polarized light between crossed nicols, will show the phenomenon of the black cross when they are round in shape, and when elongated will show four successive extinctions and illuminations for each revolution of the microscope stage.

This phenomenon is photographed and reproduced herewith. While not exactly identical, since there is inversion in the relief in relation to the surface of the sample, it is still closely akin to that presented by globular or elongated inclusions of vitreous and transparent silicates in steel. It can hardly be assumed that glycerin acquires the optical properties of a bi-refringent crystal under the simple influence of its surface tension. Observations of inclusions under the polarizing microscope should therefore not be interpreted hastily, especially when dealing with transparent or highly translucent inclusions.

Finally, the advantages of conic light in the determination of inclusions should be noted, especially in discerning opaque and transparent inclusions without the use of polarized light. This has been discussed by the writer and René Castro at the British Iron & Steel Institute meetings in September 1935 and 1936.

ALBERT PORTEVIN

Professor Portevin Refutes Idea That "Black Cross" in Transparent Inclusions in Metals Indicates Internal Stress by Showing Same Phenomenon in Glycerin Droplets on Slightly Greased Metal Surface (150 Diameters)



Parallel nicols | Crossed nicols | Same as middle but stage rotated 45°

Wear Testing

Comments on Articles in METAL PROGRESS

by Samuel J. Rosenberg
Asso. Metallurgist, Bureau of Standards

WASHINGTON, D. C. — Although the problem of wear testing has many ramifications, and differences of opinion among investigators are not uncommon, certain principles are agreed upon. One is that there is not, and can never be, a "universal" wear test. This is a logical corollary of the fact that there are many different types of wear and that a material which is most advantageous in a certain application may be useless in a different one. A consideration of these facts leads to the conclusions that wear testing equipment must be designed to simulate actual service conditions, that results from any type of wear test cannot be accepted until it has been proved that those results actually check service data, and that the rating of materials obtained by any one test cannot be applied to any different type of wear. These conclusions have frequently been confirmed by careful experimenters, and the literature is quite consistent.

There appeared, in the March 1937 issue of METAL PROGRESS, a very interesting article, "The Relative Wear of Some Hard Metals," by Robert B. Freeman. In the April issue Dr. Freeman, in collaboration with Donald S. Clark, described "A New Test for Relative Sliding Wear." The purpose of this test was to accelerate the determination of the resistance of materials to sliding wear and a few data are given to show that this test is suitable for that purpose.

The apparatus described in the March issue is designed to simulate sliding metal-to-metal wear, and when pressure, speed, and other factors are properly controlled, the authors may reasonably expect to secure data which will be applicable to service conditions involving sliding wear. The use which is immediately suggested by the description of the test is the determination of the wear resistance of materials used for brake shoes on car wheels. The accelerated test method for determining resistance to sliding wear, described in the April issue, does not involve the same type of wear which exists in the test described in the March issue. This accelerated test method is really a measure of the resistance to scratching or cutting, or a combination of both, and it is quite probable that if many materials are tested, the two testing methods will not rate them all in the same order.

A study of the data given in the March article reveals that the wear of any material in this type of test is dependent upon the material with which it is in contact, the pressure between the two and rate of slip (to mention only three factors). Since so many factors enter into the determination of the wear resistance of a metal in this machine, and some of these are altogether different and others are not even present in the cutting or scratch test method described in the April issue, it should not be expected that the latter test will give results similar to those obtained with the first.

The complexity of the problem of wear really can be appreciated only by those who have worked in this field. When one considers the amount of time and effort which has been spent in wear testing, the sum total of our knowledge on this subject is surprisingly small. One or more of the technical societies can render a real service to the metal industries by sponsoring an extended study of wear and wear testing. A program of work should include a tabulation of the various types of wear, a study of the mechanism of each type of wear and the effect of pertinent influencing factors, a critical study of all available wear testing methods and a determination of the type of wear most closely simulated by each method, and the proper interpretation of test data. All test data secured in such a study should be extensively checked against service results. Such a program, carefully planned and painstakingly executed, might lead to a sufficient understanding of wear to enable the ultimate standardization of certain types of wear tests and a clear understanding of the applicability of the test data obtained therefrom.

SAMUEL J. ROSENBERG

Reply by Messrs. Clark and Freeman

PASADENA, CALIF. — The results of wear tests carried on at the California Institute of Technology and reported by Robert B. Freeman in the March 1937 issue of METAL PROGRESS, were in answer to a direct problem concerning sliding wear. In observing the results of those tests, it was believed that for certain materials wear took place by the removal of metal by cutting or scratching. An investigation of this fact was therefore undertaken, and it is reported in the April 1937 issue.

The results of this study do not warrant the

conclusion that tests which determine the energy required to scratch a material are suitable to compare sliding wear resistance. From some comments which have been received, it is apparent that the intent of the authors was not clearly stated. It was believed that the method and results would be of interest to others and was reported with that as the motive, rather than to convey the idea of conclusiveness. It is the authors' belief, however, that under certain conditions this method may be of comparative significance.

DONALD S. CLARK
ROBERT B. FREEMAN

Sound Welds in Very Thick Plate a Routine Matter

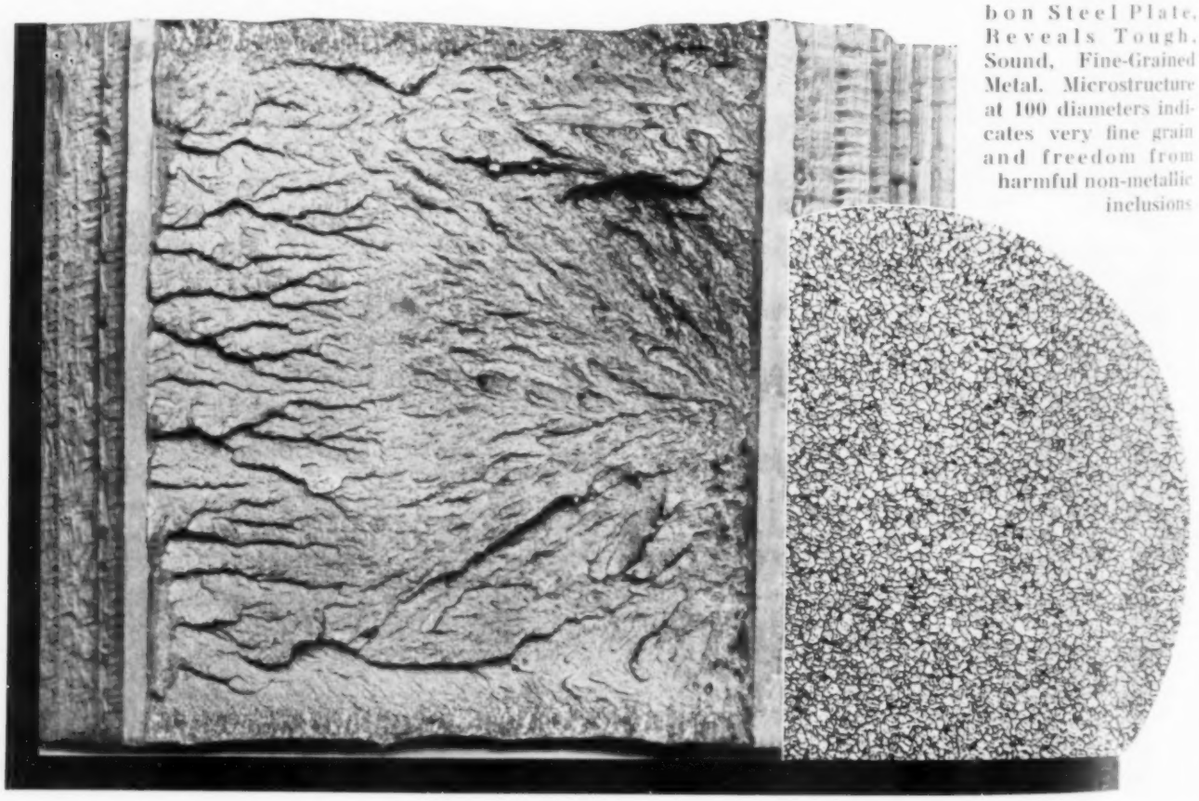
Special Note for METAL PROGRESS
by H. S. Blumberg
Metallurgist, M. W. Kellogg Co.

JERSEY CITY, N. J. — The accompanying full-sized photograph of a test fracture in a welded joint and micro at 100 diameters of the weld will indicate the tough, fine-grained and sound metal which is characteristic of modern welding when it is properly carried out. These views were taken of a test plate made in our shop with Kellogg welding rod under regular conditions in the production of large pressure vessels.

The metal is plain carbon steel, 4¼ in. thick, of 55,000 psi. tensile strength. A nick was made in both edges with a milling machine and the weld broken so that the fracture represents a longitudinal section through the approximate center of the joint. This "nick break test" was made according to the specifications in the A.S.M.E. Boiler Code and the American Petroleum Institute Code for Welded Vessels.

A somewhat columnar structure appears in the metal at the very top surface and at the bottom surface of the weld. In a completed pressure vessel most of this would be removed when excess weld metal is chipped. Microscopically, there does not appear to be a great deal of difference between this columnar edge and the finely crystalline metal deeper seated. The entire fracture can be truthfully termed "fine grained," the differences in texture appearing in the photograph being related as much to the manner in which the fracture took place as to any other factor.

H. S. BLUMBERG



Nick-Break Test, Longitudinally Through Center of Weld in 4¼-In. Carbon Steel Plate, Reveals Tough, Sound, Fine-Grained Metal. Microstructure at 100 diameters indicates very fine grain and freedom from harmful non-metallic inclusions

Embrittlement of Steels at High Steam Temperatures

Special Letter to METAL PROGRESS
by J. H. G. Monypenny
Metallurgist, Brown, Bayley's Steel Works

SHEFFIELD, ENGLAND — An increasing use of high superheats in steam plants during the last few years has brought into prominence the fact that many kinds of steel are liable to lose their toughness if exposed for long periods at 800° F., 900° F. or thereabouts. This matter is of particular importance in regard to studs and bolts used in main steam lines or other places where they are exposed practically to the full steam temperature. As such bolts are frequently highly stressed, they have been made from alloy steels of various types and some of these, which may have possessed Izod impact values of 50 ft-lb. or more when put into service, may be found after a few months' use, to give values of only 5.0 ft-lb. or so.

It may be useful to consider this matter from two aspects: *(a)* What causes the embrittlement and how may it be avoided? *(b)* What practical significance has the low impact value?

As regards the first, there can be little doubt that the embrittlement produced is similar to the "temper brittleness" which is so characteristic a feature of ordinary nickel-chrome steels when they are tempered between about 750° F. and 1000° F., or are cooled otherwise than quickly from higher tempering temperatures. There is this difference, however: Nickel-chrome steel may lose the greater part of its notch toughness as a result of heating for two or three hours at 900 to 950° F., for example, whereas the embrittlement of some of the alloy steels proposed for high temperature steam bolts may develop only after a service period of as many months. This difference would appear to be solely one of *rate* of development; the fundamental causes of the two types of embrittlement are probably the same. In spite of many investigations, however, this fundamental cause is still unknown.

Fortunately a palliative is known. If molybdenum be added to nickel-chrome steels, the tendency toward temper brittleness is greatly retarded; 0.3% molybdenum will prevent any evidence of this defect appearing under ordinary heat treatment conditions. On the other hand, continuous service at 800° F. or 900° F. necessitates much larger additions; thus, steel containing 0.61% molybdenum (with 2.27% nickel and 0.66% chromium) has been shown by Dr. Inglis to lose 60% of its impact value after 15 months at 410 to 430° C. (770 to 806° F.). This information is contained in a paper by N. P. Inglis on "The Relationship between Mechanical Tests of Materials and their Suitability for Specific Working Conditions" before the North-East Coast Institution of Shipbuilders & Engineers, December 1936. Similar additions of molybdenum to steels which are themselves much less liable to develop temper brittleness — that is, to carbon steels or to chromium steels — produce materials which appear to retain their toughness indefinitely at such temperatures.

So much for the loss in notch brittleness in high temperature service. Opinions as to the practical significance of this embrittlement are not unanimous. It is often stated that the brittleness is only evident in the impact test. This is not strictly true, although it is agreed that no measurable difference between the tough and embrittled forms of the steel is observable in tensile, bend or fatigue tests providing the test pieces are not notched. Slow bending tests or impact tensile tests on suitably notched test pieces, however, show differences similar to those in the Izod impact test, so that the embrittlement produced would appear to be associated with local intensification of stress due to the presence of a notch, a matter surely of importance in threaded studs and bolts.

A further important feature is the effect of testing temperature on the value obtained in the impact test. Some eighteen years ago, the present writer showed in the *Journal* of the Iron & Steel Institute, 1919, Vol. II, p. 398, that the impact value obtained from temper brittle nickel-chrome steel increased slowly as the testing temperature was raised to 250° C., then rapidly between 250° C. and 300° C., and at 350° C. (650° F.) the value obtained was equal to that possessed by the tough form of the same steel. Similar results have recently been obtained by Dr. Inglis on material embrittled by prolonged exposure at high steam temperatures. Hence, if embrittlement is produced in a stud or bolt or other part exposed for long periods to high steam heats, that embrittlement only becomes evident when the bolt or other part cools down below about 250° C.; it does not exist at the operating temperature.

This fact is of considerable importance, but it does not settle the question as to the danger of embrittlement from a practical standpoint. Power plants do not remain continuously in use

during the whole period of their useful life. If the structural changes producing embrittlement — whatever they may be — have occurred in a bolt or stud, embrittlement will become evident during stoppages, whenever the bolt or stud cools below about 250° C. One can easily visualize conditions in practice in which the stresses (either tension or bending) on such bolts will be greater during the warming-up period after a shutdown than when the plant is working under steady load.

It is also occasionally necessary for a bolted joint to be broken for insertions of new fittings or alterations to steam line or other causes. Those who have been so unfortunate as to have to do this with bolts of embrittled steel do not generally wish to repeat the operation!

Finally, one may consider the matter from the point of view of strength at service temperatures. It is fortunate that those varieties of steel — for example molybdenum and chrome-molybdenum — which are free from embrittlement effects are also among the strongest at these temperatures. It does not appear that other kinds of steel, such as nickel-chrome and certain commercial types of nickel-chrome-molybdenum steels, which are subject to embrittlement offer any advantage, either economic or from the standpoint of physical properties, which might be set against their loss of toughness. It may be suggested, therefore, that the wisest course is to select for these highly stressed parts, steels that do not embrittle as a result of service conditions even though the embrittlement which might be produced in other steels may affect the stud or bolt, for which they were used, during only a fraction of its life.

J. H. G. Monypenny

Titanium Does Not Increase Corrosion of 18-8 Stainless Steel

Comment on Article in Metal Progress
by William B. Brooks
Metallurgist, Stainless Steel Division
Carnegie-Illinois Steel Corp.

PITTSBURGH, Pa. — In a letter published in the May issue from Eduard Maurer of the Freiberg School of Mines (Germany) it was stated that: "Titanium steels are troublesome to work because of their tendency to form a thin scale, likely to be troublesome in the fabrication of sheet." We have produced in this country many tons of 18-8 sheets containing titanium which have been subject to numerous difficult fabricating operations and no trouble at all has been encountered of the nature described by Professor Maurer.

The tendency of titanium steel to scale cannot be considered significant because one of the most notable applications of this grade of steel has been in airplane exhaust manifolds, which often operate as high as 1600° F.

It was further stated that general corrosion is increased somewhat by the addition of titanium and tantalum and the German steel impaired in this respect. Occasionally in the past trouble has been encountered in the manufacture of titanium bearing stainless steels which has been caused by dirt. We have, however, been able to overcome this difficulty completely and find that when properly manufactured, titanium bearing stainless steels possess a resistance to corrosion fully equal to corresponding analyses which do not have the titanium addition. William B. Brooks

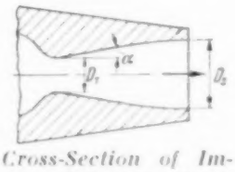
Smooth and Rapid Flame Cutting of Plate 8 In. Thick

Special Letter to Metal Progress
by Hans Diergarten
Metallurgist, SKF Bearing Co.

SCHWEINFURT, Germany — Flame cutting has sufficient technical significance to warrant a report of some new information on the subject. Theodor Zobel, as the result of some investigations in the Welding Research Department of the Berlin School of Technology, has published a pamphlet on the subject of "Increasing the Speed of Flame Cutting With New Forms of Blowpipe Nozzles" (Press of the Verein deutscher Ingenieure).

This little booklet starts with the historical development of flame cutting (and a bibliography), after which Dr. Zobel reports the results of his own experiments. The first requirement was to procure high speed motion pictures of the oxygen jet as it emerged from the cutting blowpipe, which was done with the aid of a system of prisms constituting an interferometer.

On the basis of numerous experiments the special type of nozzle shown in the sketch was developed. It produces a parallel stream of oxygen, whereas other nozzles with cylindrical orifices or slightly converging conical orifices produce a jet



Cross-Section of Improved Cutting Nozzle

(Continued on page 74)

AT YOUR SERVICE . . . TO CUT COSTS

A Chrome-Molybdenum (4120) carburizing steel is now available for mass production. It brings the cost of carburized parts down to new and more practical levels. It costs less than any other high-grade alloy carburizing steel. Its core properties are equal to those of the more expensive grades.

Made to controlled grain size, it:

1 Is low in cost.
2 Quenches from the box with minimum uniform distortion.
3 Takes a very hard, scuff-resistant case.
4 Develops good core properties.
5 Has excellent machinability.

Thanks to these qualities, it has already met the requirements of one of the toughest assignments — automotive hypoid gears — and has cut the production costs considerably.

It will cut costs, and improve performance, on any job where maximum core properties are not essential. Write for details — investigation will pay. . . . Climax Molybdenum Company, 500 Fifth Avenue, New York City. *Not yet officially registered by the S. A. E.

PRODUCERS OF FERRO-MOLYBDENUM, CALCIUM MOLYBDATE AND MOLYBDENUM TRIOXIDE

Climax Mo-lyb-den-um Company

MOLY

PERSONALS

George B. Waterhouse, professor of metallurgy, Massachusetts Institute of Technology, has been nominated for president of the American Society for Metals.

William P. Woodside, vice-president, Climax Molybdenum Co., Detroit, has been nominated for vice-president, and **Bradley Stoughton,** dean of the Engineering Department, Lehigh University, for treasurer.

James P. Gill, chief metallurgist, Vanadium-Alloys Steel Co., Latrobe Pa., and **Harvey A. Anderson,** metallurgical engineer, Western Electric Co., Chicago, have been nominated for trustees.

R. B. McEachern is now in the Engineering Department, Harris Calorific Co., Cleveland.

Stuart Oils

FOR THE "TOUGHEST" METAL WORKING CONDITIONS

? Is Deep Drawing Of Stainless Steel a Problem with You?

IF SO, WIRE OR WRITE AT ONCE FOR FREE WORKING SAMPLE OF

Stuart's "SUPER-KOOL"

EXTRA HEAVY DUTY

DRAWING COMPOUND

A thoroughly tested deep drawing lubricant widely recommended by leading makers of stainless steel, and in daily use by well known production plants.

Stuart's "SUPER-KOOL" sprayed or brushed on the stock prevents metallic seizure and allows proper slippage when angles are sharp and where pressures are extremely high. Containing no pigment its cleanability is an interesting factor to many plants.

Address request for free sample to
General Offices, 2727-2753 South Troy Street, Chicago

D. A. STUART & CO.
ESTABLISHED 1865
CHICAGO U. S. A.
Warehouses in Principal Industrial Centers

A. H. Allen, formerly associate editor of *Steel*, has been transferred to the new Detroit office as Detroit editor.

Albert Easton White, past president, director, Department of Engineering Research, University of Michigan, has been nominated for president of the American Society for Testing Materials.

Richard Laurence Templin, chief engineer of tests, Aluminum Co. of America, and **H. C. Mougey**, assistant technical director and chief chemist, Research Laboratories, General Motors Corp., Detroit, have been nominated to the Executive Committee of the American Society for Testing Materials.

R. R. LaPelle has severed his connection with the Salem Engineering Co. and joined the staff of the Philadelphia Drying Machinery Co.

Robert Lillie is a junior metallurgist at Carnegie-Illinois Steel Corp., Gary Sheet Mill.

Arthur Marmory, late of Paramount Cab Corp., Hagerstown, Md., has accepted a position as manager of the Production Control Department, Buffalo Works, Worthington Pump & Machinery Corp.

Zay Jeffries, past president, received the honorary degree of Doctor of Science from Case School of Applied Science.

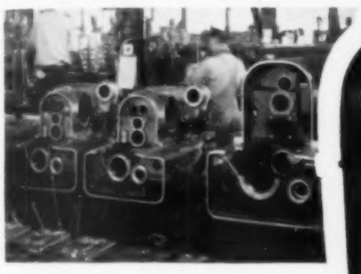
E. B. Evleth has been appointed vice-president and general manager of The Brown Instrument Co., Philadelphia. **Charles L. Saunders**, former regional sales manager, has been promoted to succeed Mr. Evleth as resident vice-president in charge of the Midwest Region for the Minneapolis-Honeywell Regulator Co.

C. R. Culling, vice-president, Carondelet Foundry Co., St. Louis, Mo., has been nominated for a director of the Gray Iron Founders' Society, Inc., for the year 1937-38.

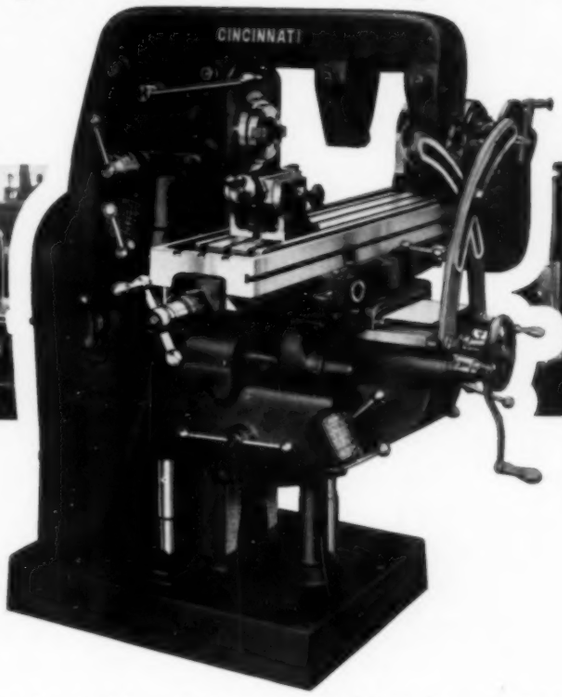
MEEHANITE

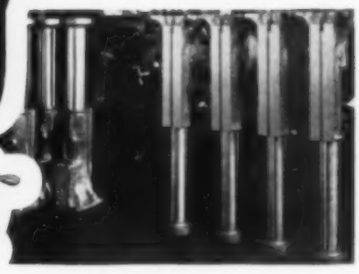
• MACHINE TOOL CASTINGS •

Increase Strength • Reduce Weight • Improve Finish



Intricate cored castings combining both light and heavy sections are produced successfully.





Note the fine finish on the Upright Drill Columns made in Meehanite.

Many machine tools throughout the world are today built in Meehanite—replacing both more costly and less suitable materials.

• MEEHANITE OFFERS •

Rigidity . . . Greater strength . . . Higher resistance to impact . . . Excellent damping characteristics . . . Better endurance against fatigue . . . Higher resilience . . . Good bearing qualities . . . Maintenance of accurate dimensions . . . Good Machinability . . . Special properties by heat treatment

Meehanite castings are produced under most modern methods and rigid Metallurgical Control.

Meehanite frequently permits redesigning, using thinner sections, and a reduction in overall weight.

Meehanite assures outstanding mechanical improvements in the part for which used.

American Laundry Machinery Co. . . . . Rochester, N. Y.
Banner Iron Works . . . . . St. Louis, Mo.
H. W. Butterworth & Sons Co. . . . . Bethayres, Pa.
Cincinnati Grinders Incorporated Cincinnati, Ohio
The Cincinnati Milling Machine Co. . . . . Cincinnati, Ohio
Cooper Bessemer Corporation . . Mt. Vernon, Ohio
Crawford & Doherty Foundry Co. Portland, Oregon
M. H. Detrick Co. . . . . Peoria, Ill.
Farrel Birmingham Co. . . . . Ansonia, Conn.
Florence Pipe Foundry & Machine Co.
R. D. Wood Company, Philadelphia
Selling agents

METAL

Fulton Foundry & Machine Co. . . Cleveland, Ohio
G.H.B. Foundry Co. . . . . Dayton, Ohio
Greenlee Foundry Company . . . . . Chicago, Ill.
Hamilton Foundry & Machine Co. Hamilton, Ohio
Kanawha Manufacturing Co. . . Charleston, W. Va.
Kinney Iron Works . . . . . Los Angeles, Calif.
Koehring Company . . . . . Milwaukee, Wis.
Michigan Valve & Foundry Co. . . . . Detroit, Mich.
Rosedale Foundry & Machine Co. . Pittsburgh, Pa.
Ross-Meehan Foundries . . . . . Chattanooga, Tenn.
Vulcan Foundry Company . . . . . Oakland, Calif.
Warren Foundry & Pipe Corporation . . . . . Phillipsburg, N. J.
Washington Iron Works . . . . . Seattle, Washington

PERSONALS

Carl B. Sunderland has been appointed zone representative for Roots-Connersville Blower Corp. covering Indiana, Ohio, Michigan, Illinois and Kentucky. **J. J. Heinrikson** will cover western Missouri, Kansas, most of Nebraska, and the southwestern quarter of Iowa. **Paul C. Rowe** will cover northern New Jersey.

G. R. Harris and **M. H. Banta** have been transferred from the Jones & Laughlin Steel Corp. Aliquippa Works to the new Research and Development Division at Pittsburgh.

A. W. Sikes has been transferred from Washington, D. C., to the Chicago office of the Public Works Administration, Engineering Division.

Only Chapmanizing

GIVES YOU THESE 4

HEAT-TREATING ADVANTAGES

Design and production engineers find unexpected opportunities for product improvement and cost reduction in these characteristics of the Chapmanizing process for surface-hardening steels:

1. **Low-cost steels are given the hardness of costly alloys — up to 1000 Brinnell.**
2. **In ⅓ the time, Chapmanizing gives a surface that outwears carburizing 9 to 1. Machining and grinding time is also cut.**
3. **Case of any depth from .002" to .035", tough yet ductile . . . won't chip, flake, corrode, warp, distort.**
4. **No capital investment. Use your present set-up . . . install the Chapmanizing Unit on a contract basis.**

Send for new illustrated book containing complete engineering information.

S.A.E. 1020 STEEL CHAPMANIZED 2 HRS.
CHAPMANIZED
NITRIDING STEEL NITRIDED 70 HRS.
NITRIDED
S.A.E. 1020 STEEL CARBURIZED 10 HRS. CARBURIZED
1 2 3 4 5 6 7 8 9 10 11 12 13 14
WEAR Numbers indicate loss of weight in .001 grams per sq. in.— after 30,000 strokes, metal to metal, dry.
The
CHAPMAN
VALVE
MANUFACTURING CO.

INDIAN ORCHARD, MASSACHUSETTS

John Wilbur has been transferred from the New York to the Cleveland office of Electro Metallurgical Sales Corp.

Paul A. Jennings has been transferred to the Metallurgical Department of the National Tube Co., Ellwood Works.

Paul E. Timmerman has left the John Deere Tractor Co. to take a position with the Process Development Section, Linde Air Products Co., Newark, N. J.

F. V. Lenel has left Hardy Metallurgical Co., New York, to join Moraine Products Division, General Motors Corp., Dayton, Ohio, as metallurgist.

W. Frank Detwiler, heretofore executive vice-president, has been elected president of Allegheny Steel Co.

Charles A. Van Bergen has been appointed representative and application specialist for roll-neck bearings for General Electric Co., Bridgeport, Conn.

John W. White has been elected vice-president and general manager of Westinghouse Electric International Co., New York City.

Collier Elliott, formerly with R. H. Macy & Co., Inc., is now in the New York office of Peter A. Frasse & Co., Inc.

W. Herbert Bretzlaff has been appointed vice-president of The Defiance Pressed Steel Co., Toledo, Ohio.

H. N. Davis, president, Stevens Institute of Technology, Hoboken, N. J., has been nominated for president of the American Society of Mechanical Engineers. **F. O. Hoagland**, **B. M. Brigman**, **Harte Cooke**, **W. H. McBryde**, and **L. W. Wallace** have been nominated for vice-presidents, and **Carl Bausch**, **S. B. Earle** and **F. H. Prouty** for managers.

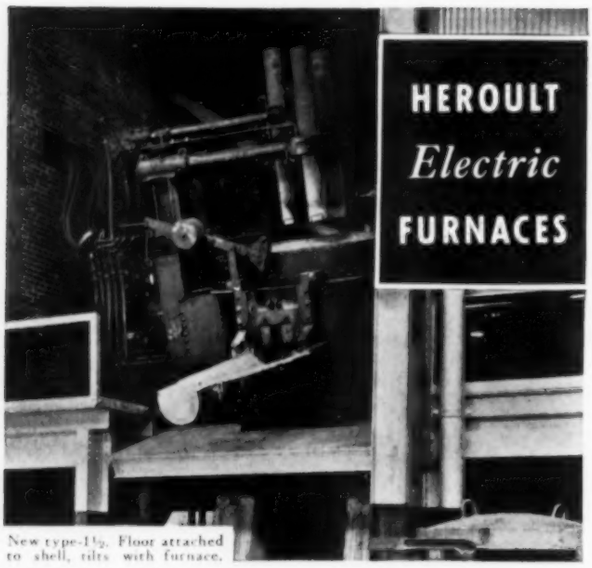
E. E. Wright has been appointed to take charge of the Cleveland office of Electro Metallurgical Sales Corp.

Whitey Sez:

"It's not necessary to worry about your station in life—as someone is ever ready to tell you where to get off . . . although a reputable product did take me to the coast and back."

MAURATH, INC., CLEVELAND

BUILDER OF BETTER WELDING ELECTRODES IN ALL ANALYSES



New type-1½ Floor attached to shell, tilts with furnace.

USE them for efficient melting and refining of all kinds of ferrous materials by either basic or acid process—including alloy, tool and forging steels, iron and steel castings. Any capacity from ½ ton to 100 tons; removable roof, chute, machine or hand charging.

AMERICAN BRIDGE COMPANY

General Offices: Pittsburgh, Pa.
Offices in the larger cities
Columbia Steel Co., San Francisco, *Pacific Coast Distributors*
United States Steel Products Co., New York, *Export Distributors*

UNITED STATES STEEL

Popular Polisher

Features such as direct drive, vibrationless interchangeable discs, definite speeds 575 and 1150 R.P.M., made this the most popular polisher now in use from coast to coast.

Adolph I. Buehler
OPTICAL INSTRUMENTS • METALLURGICAL APPARATUS
228 NORTH LA SALLE ST. • • CHICAGO ILL.

(Continued from page 68)

which expands in diameter shortly after leaving the tip. In the sketch, diameter D_1 is 1.5 mm. (0.059 in.), D_2 is either 2.5, 3.0, or 3.5 mm. (0.098, 0.118 or 0.138 in.) and angle α is 7°, 8°, 9° or 10°.

The aim of the investigation was to increase the cutting speed and thus reduce the cost by improving the flow of cutting oxygen through the nozzle.

This special design produces an oxygen jet which emanates from the nozzle as a parallel stream, without sudden loss of energy by expansion from the nozzle pressure to the atmospheric pressure; this jet therefore retains its form over a considerable length of path. A prime advantage over the older type of nozzle lies in the fact that the favorable properties of this jet are not changed even by very high gas pressures.

With the use of the new nozzle the conception of critical speed or limiting speed, which is practically the highest speed possible in industrial applications, loses its former significance. Cutting speeds of 20 in. per min. on 1-in. plate are quoted by Dr. Zobel, in comparison with 9 in. per min. as an average for three commercial nozzles. Speeds of 14 in. per min. on 4¾-in. plate and 7¾ in. per min. on 8-in. plate also are far greater than former averages (5 and 3½ in. per min. respectively).

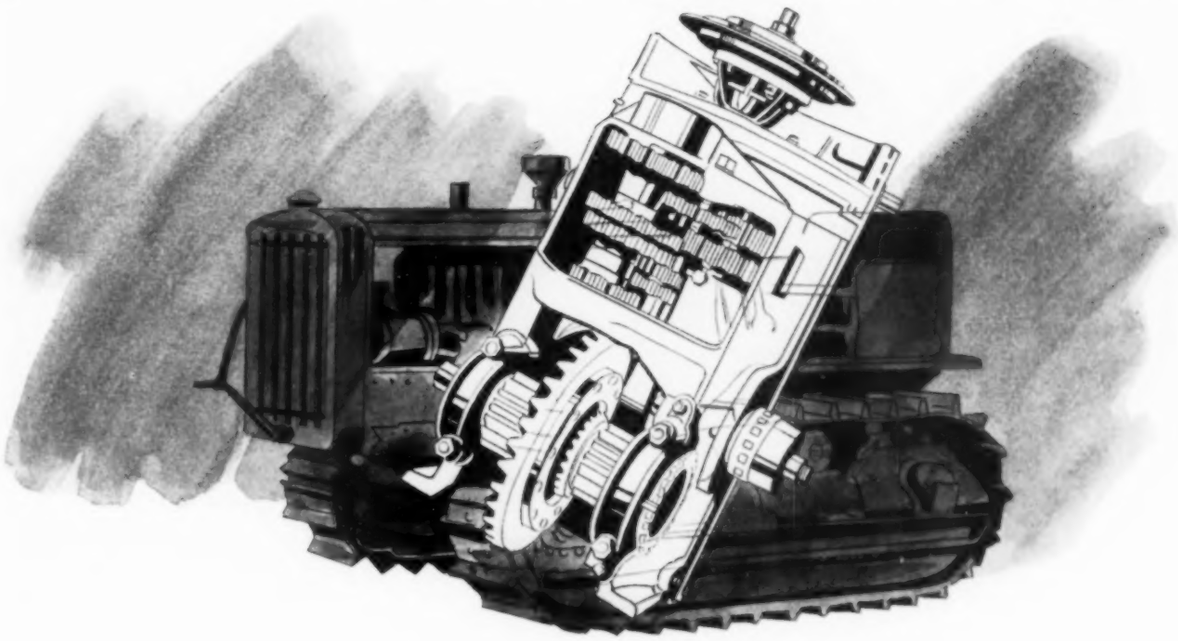
Pressures required to attain this upper limit of cutting speed are 90 psi., 265 psi. and 340 psi. respectively. Higher pressures do not affect the quality of the cut but only affect the cost. Using the ordinary nozzles, even with a high expenditure of oxygen, the above quoted speeds attainable by the new nozzle cannot be reached.

A good cut with clean, smooth surface is not dependent on the penetration of the cutting flame in a truly perpendicular line. With the type of oxygen jet provided by the new nozzle, a sloping cut may be made at high speed without impairing the quality of the surface. An expanding oxygen jet will cause a wavy surface, the crests and troughs of whose waves are parallel to the top surface of the plate, and this is due to the ricocheting of expanding gas streams from side to side of the channel or kerf as it is formed. Thus the form of the cut groove depends on the form of the jet of cutting oxygen. Only the parallel stream fills the requirements for a smooth cut surface as well as low cost, since it provides the highest energy of flow for the smallest diameter of the jet.

A practical result of this work is that steel is being cut with modern precision at one-half to two-thirds the cost of cuts made by older equipment.

HANS DIERGARTEN

for RUGGEDNESS



CASE-HARDENING WITH DU PONT CYANIDES PROVIDES CARBON FOR HARDNESS—NITROGEN FOR WEAR-RESISTANCE

DU PONT
REG. U.S. PAT. OFF.

R. & H. CYANIDES

CYANEGG*
Sodium Cyanide,
Minimum Strength, 96%

Cyanide Chloride Mixture
75% Sodium Cyanide

Cyanide Chloride Mixture
45% Sodium Cyanide

Du Pont Case Hardener
30% Sodium Cyanide

*Reg. U.S. Pat. Off.

A TRACTOR has to be rugged. To stand up under sudden, heavy impacts, slush, abrasive grit and exposure to a wide range of temperature its parts must have extreme resistance to wear and abrasion.

The life of moving parts in automotive and other equipment can be increased by heat-treating with du Pont Cyanides. *In one operation*, the nitrogen needed for maximum wear resistance and the carbon for hardness are introduced from the molten Cyanide bath into the steel surface. Distortion is kept to a minimum and no finishing operations are required.

Cyanide hardening is the economical and efficient method for obtaining extreme wear resistance and surface hardness with minimum distortion in plain carbon, oil-hardening alloy and carburized steels. The bath is non-corrosive. There is no scale. The guaranteed content of du Pont Cyanides permits the preparation of molten baths of definite strength, necessary for proper control.

Our Technical Service Staff will gladly cooperate with you in the selection and use of the proper du Pont Cyanide to meet your individual shop conditions.

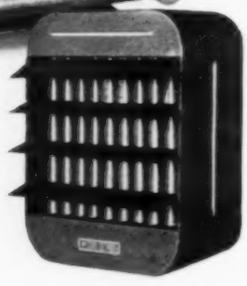
SEND FOR INFORMATIVE LITERATURE

DU PONT
REG. U.S. PAT. OFF.

The R. & H. Chemicals Department
E. I. DU PONT DE NEMOURS & COMPANY, INC.
Wilmington, Delaware

District Sales Offices: Baltimore, Boston, Charlotte, Chicago, Cleveland, Kansas City, Newark, New York, Philadelphia, Pittsburgh, San Francisco

Brazing thin copper tubing to bronze headers with SIL-FOS in the construction of McCord Radiator & Mfg. Co. Unit Heaters.



Sil-Fos

gives

life-time strength

to heating elements in unit heaters . . .

The heating element is the very heart of a unit heater. The joints between the tubing and headers or return bends used in constructing them must be permanently tight. To assure this, and the trouble-free operation which results, McCord and other well known makers use SIL-FOS . . . because

- **SIL-FOS gives high joint strength — as high or higher than the metal joined.**
- **Ductile SIL-FOS joints stand up reliably under wide temperature changes and constant vibration.**
- **SIL-FOS, free-flowing at the low temperature — 1300° F.— makes sound joints without damaging the physical qualities of metals.**
- **SIL-FOS assures economy — a small quantity does a perfect job . . . the low brazing temperature saves time, gases and speeds up production.**

TRY SIL-FOS

on *your* non-ferrous work

Use it with our low temperature Handy Flux. Together they work equally well on thin or heavy gauges, on production or special work. Write us for full details and Bulletin 57--M.P.

HANDY AND HARMAN

82 Fulton St., New York

BRIDGEPORT, CONN. PROVIDENCE, R. I. TORONTO, CANADA

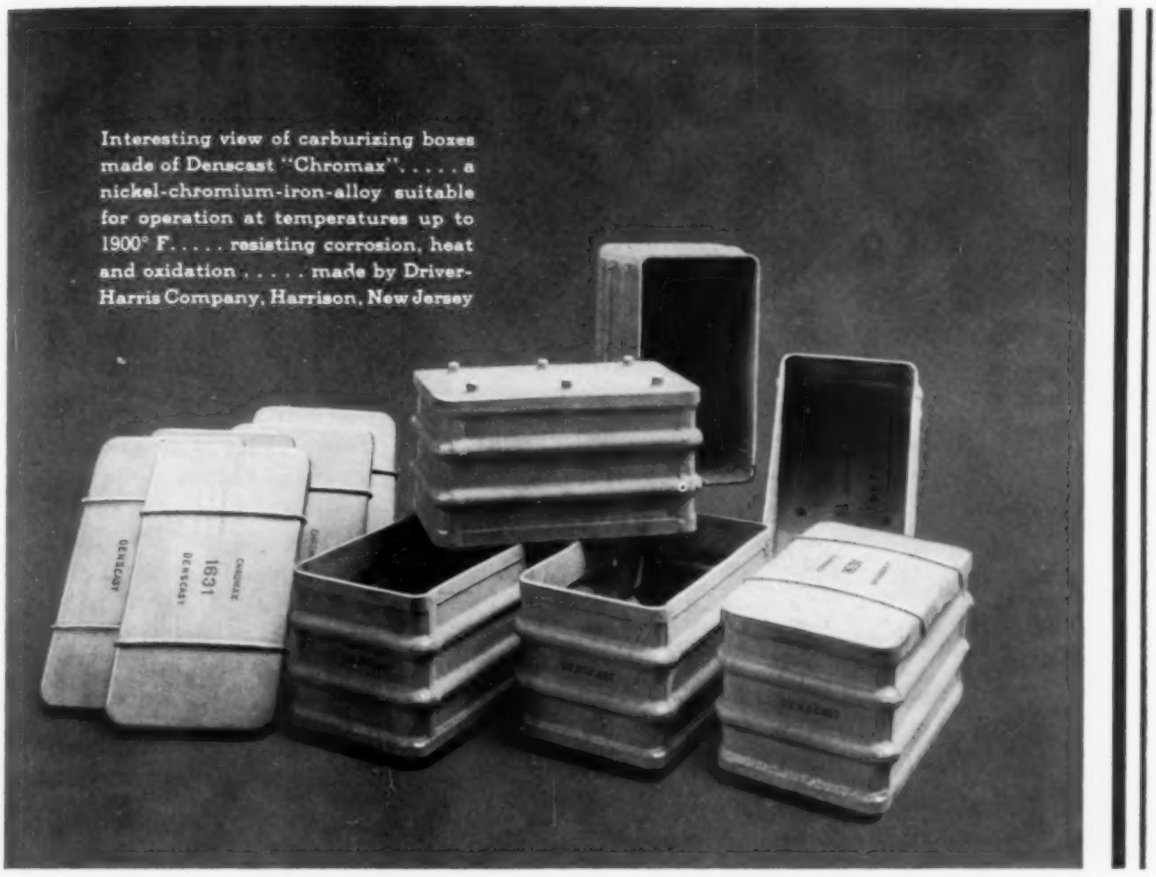
(Continued from page 52)

were made, and it was found that a preparation consisting approximately of the monobasic phosphate gave the best results. For convenience it was found desirable to embody the phosphate in a paste, by intimately mixing the powdered phosphate with an approximately equal weight of ethylene glycol, and on this British patent No. 400,609 has been issued. Superior results were evident in comparative exposure tests of soldered joints (not cleaned of flux residue) of six months' duration. Soldering was easy on brasses, mild steel and austenitic and corrosion resisting steel, without special preliminary surface treatment other than removal of heat treatment scale. This was done with flux made of 51 cc. commercial aniline, 34 cc. phosphoric acid (sp. gr. 1.75) and 40 cc. commercial ethylene glycol.

The results obtained indicate that the useful properties of phosphoric acid as a flux for soft soldering may be obtained in a substantial degree without the various disadvantages by using it in more or less complete combination with volatile organic bases, aniline in particular, and in a convenient vehicle. When such fluxes are heated in soft soldering operations the organic phosphates undergo partial decomposition. It is evident that the hot phosphoric acid thus liberated can exert satisfactory etching or cleaning effect on the material being soldered, provided the latter is initially free from heavy films of oxide or foreign matter, and so far as many of the common metals and alloys are concerned.

Results of corrosion tests suggest that the small amount of phosphoric acid and the organic phosphate remaining in flux residues on soldered work are free from objectionable corrosive effects on long standing in contact with the metals and alloys investigated. Experiments with phosphoric acid alone indicate that residues of the acid cause the formation of protective films on the materials examined, and it would appear that similar films are produced in samples soldered with fluxes containing organic phosphates as the active constituent.

In addition to the advantages of freedom from corrosive effect of residues, the phosphate fluxes are more effective than fluxes containing zinc chloride in soft-soldering many common types of material, such as corrosion resisting steels, aluminum bronze, zinc and cadmium.


Interesting view of carburizing boxes made of Denscast "Chromax"..... a nickel-chromium-iron-alloy suitable for operation at temperatures up to 1900° F..... resisting corrosion, heat and oxidation ..... made by Driver-Harris Company, Harrison, New Jersey

Roots
CONNERSVILLE
POSITIVE DISPLACEMENT AND CENTRIFUGAL
BLOWERS
FOR BOOSTING GAS PRESSURES AND
SUPPLYING AIR FOR COMBUSTION
IN HEAT TREATING FURNACES
ROOTS-CONNERSVILLE BLOWER CORP. — CONNERSVILLE, IND.

LET MAHR OFFER "PRACTICAL SOLUTIONS"

THIS BOOK TELLS YOU OF SPECIAL JOBS HANDLED WITH MAHR STANDARD FURNACES... SEND COUPON BELOW FOR YOUR COPY

● Better metal heating for less expenditure... is often possible thru the use of Mahr Standard Furnaces. Years of special furnance building have resulted in engineering experience and manufacturing practice which make possible these Standard Units for work that might otherwise call for special design.

MAHR MANUFACTURING COMPANY
DIVISION OF DIAMOND IRON WORKS, INC.
MINNEAPOLIS, MINNESOTA, U.S.A.

Gentlemen:
Kindly send us (without any obligation) your descriptive catalog on "Mahr Standard Furnaces for Special Requirements." Yours truly

BY_____

POSITION_____

MAHR MANUFACTURING COMPANY
Division of Diamond Iron Works, Inc.
MINNEAPOLIS, MINNESOTA, U. S. A.

CRYSTALLOGRAPHY

(Continued from page 41) interphase in which the molecular groups are formed, inside which the geometric configuration is already close to that of the solid lattice. The boundaries of these groups may cause discontinuities in the solid crystal. Furthermore, these boundaries form an internal surface of definite area in the large solid crystal."

P. P. Ewald and M. Renninger studied the mosaic texture of rock salt by X-ray diffraction and found that within the same crystal, the "block" boundary characteristics vary according to the physical property under investigation. This has been confirmed by my own work and the abstract of Mr. Northcott's article.

I believe that the network of the veining boundaries is not related to the slip planes of the blocks. In other words, the internal surface of the veining network is independent of the internal surface created by slight or large plastic deformations. H. Pulsifer has demonstrated that the "block-like" characteristics of the grains persist even after the most drastic cold working, and this demonstration is a most useful contribution to the imperfection theory.

Internal surface can also be created during heat treatment of metals, and the displacements are "block-like" in character. Nusbaum and the writer proved this experimentally in 1934.

The X-ray diffraction method is one which can be used to advantage in studies of this kind. The Laue spots are slightly diffused or broadened when the grains are veined; this, therefore, is a sensitive method for detection of block structure where the "block" displacement between adjacent "blocks" is small.

Many investigators feel that new experimental methods must be devised before further progress can be made in this field. While not denying this, it is my opinion that the many useful tools and methods now known to us have not been exhausted. Consider only the X-ray method; it offers unlimited possibilities provided we interpret correctly certain diffraction phenomena. This was discussed in my paper, last October, for the ASM Convention (*Transactions*, December, 1936). Some characteristics may be influenced by "block displacements," others by "fibrous textures." In turn these are fundamentally related to the change in properties of cold-worked metals when heated slightly (below recrystallization temperatures).